Energy as a Global Issue

ECSAC - Workshop on Geothermal Energy

Velj Lošinj, August 25th, 2014

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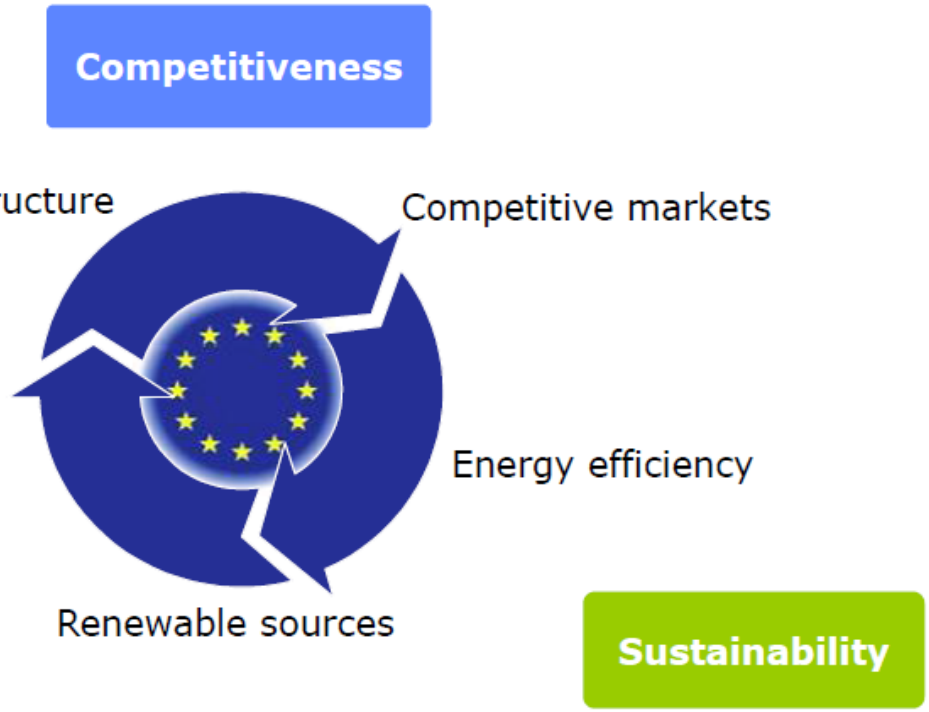
The key strategic framework

A "no regrets" scenario for Europe



Presentation of J.M. Barroso to the European Council, 22 May 2013

Contents

- Energy as a **complex,** global issue
  - Interconnectedness with global issues
  - Many new players
- The «**Energy Chain**»: from the source to the final use
  - Key role of energy efficiency and savings
- **Trends and outlooks** in energy demand, supply and price
  - The disruptive role of gas
  - Lessons learned from photovoltaics
- Tools for assessing **energy quality**
- **Trends** in energy technology
- The **Peri-Adriatic** Region

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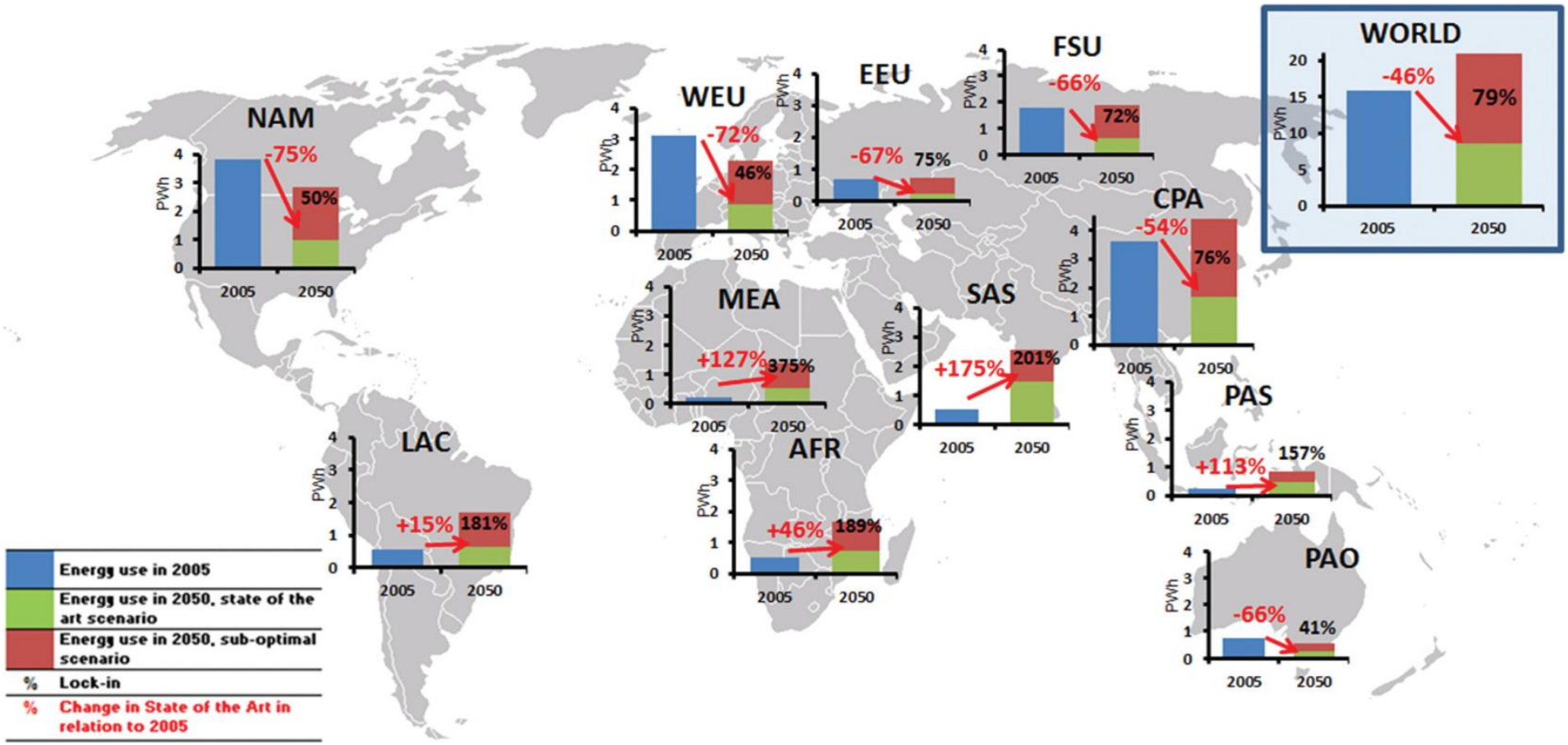
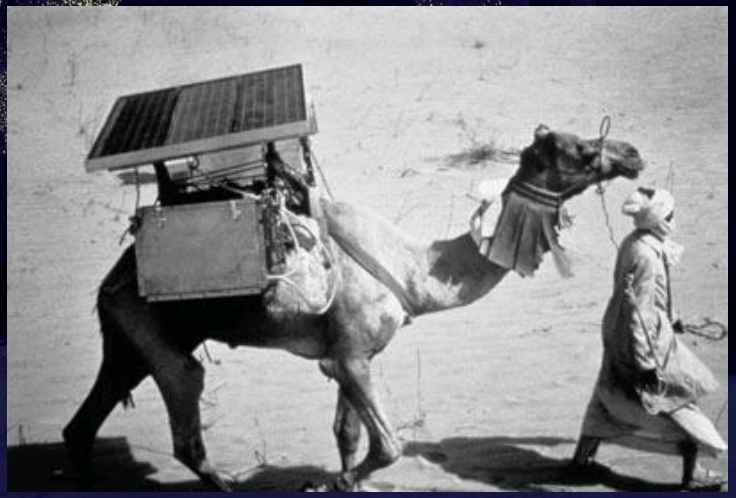
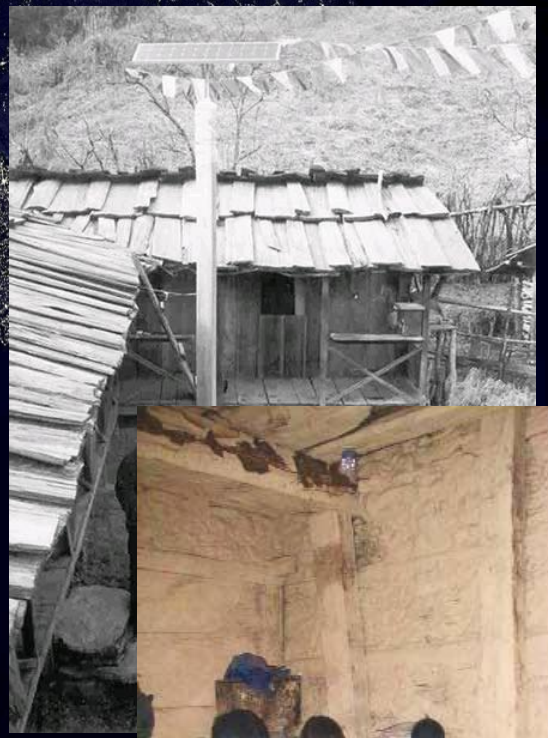
Energy: A global issue - complexity


Earth at Night

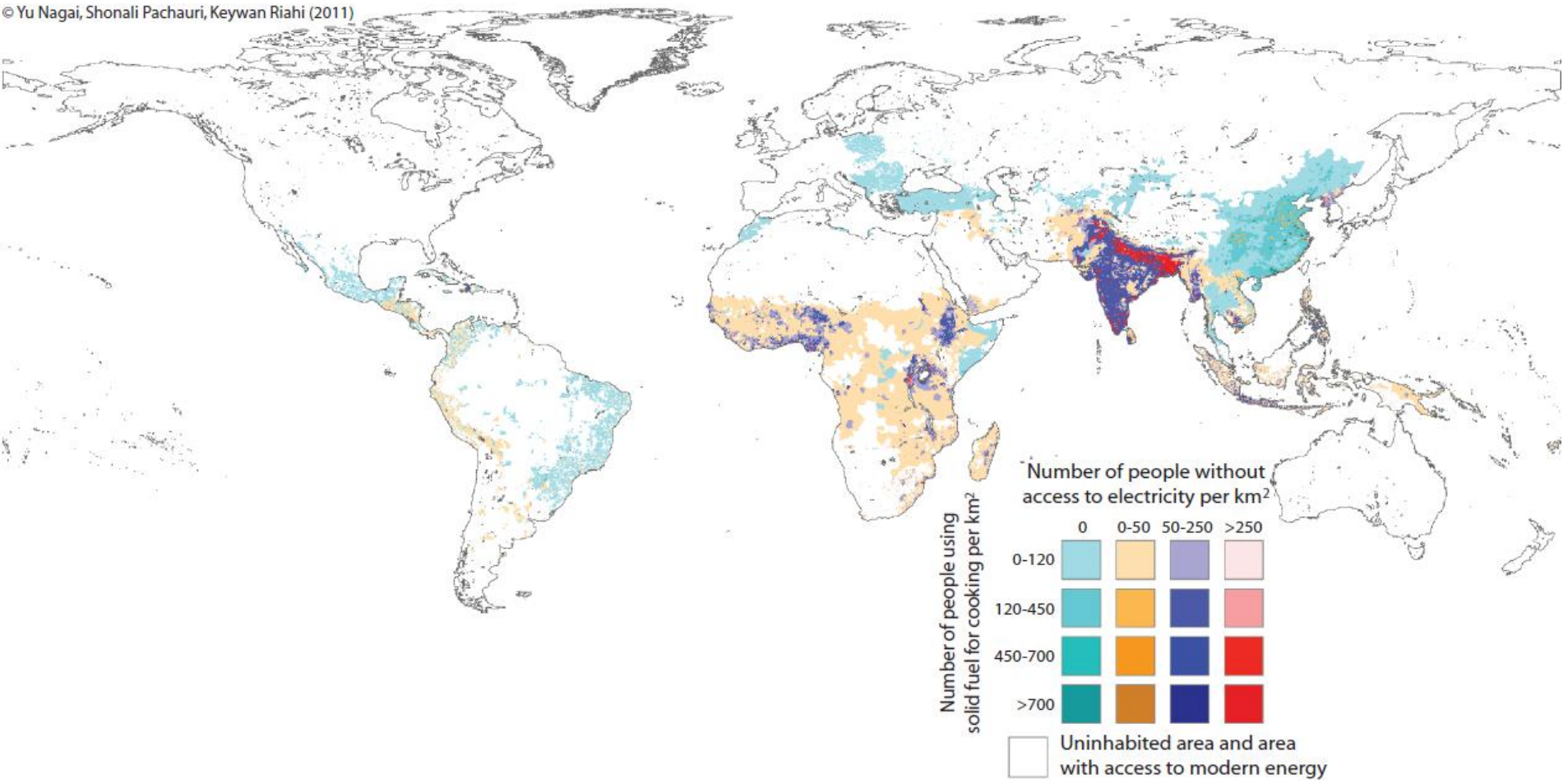
Energy use forecast





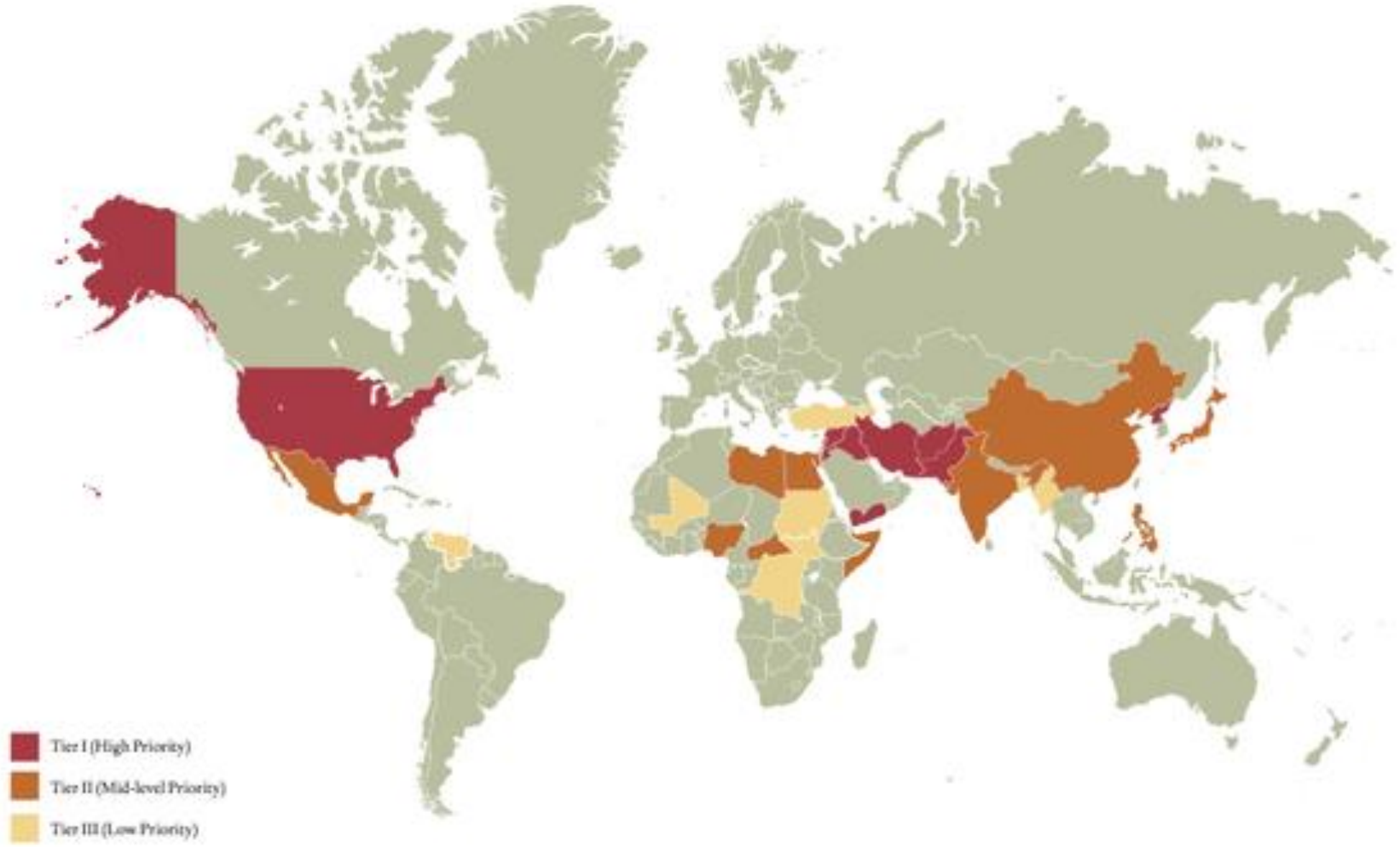


Energy, stability and security



GEA - Global Energy Assessment Report 2012

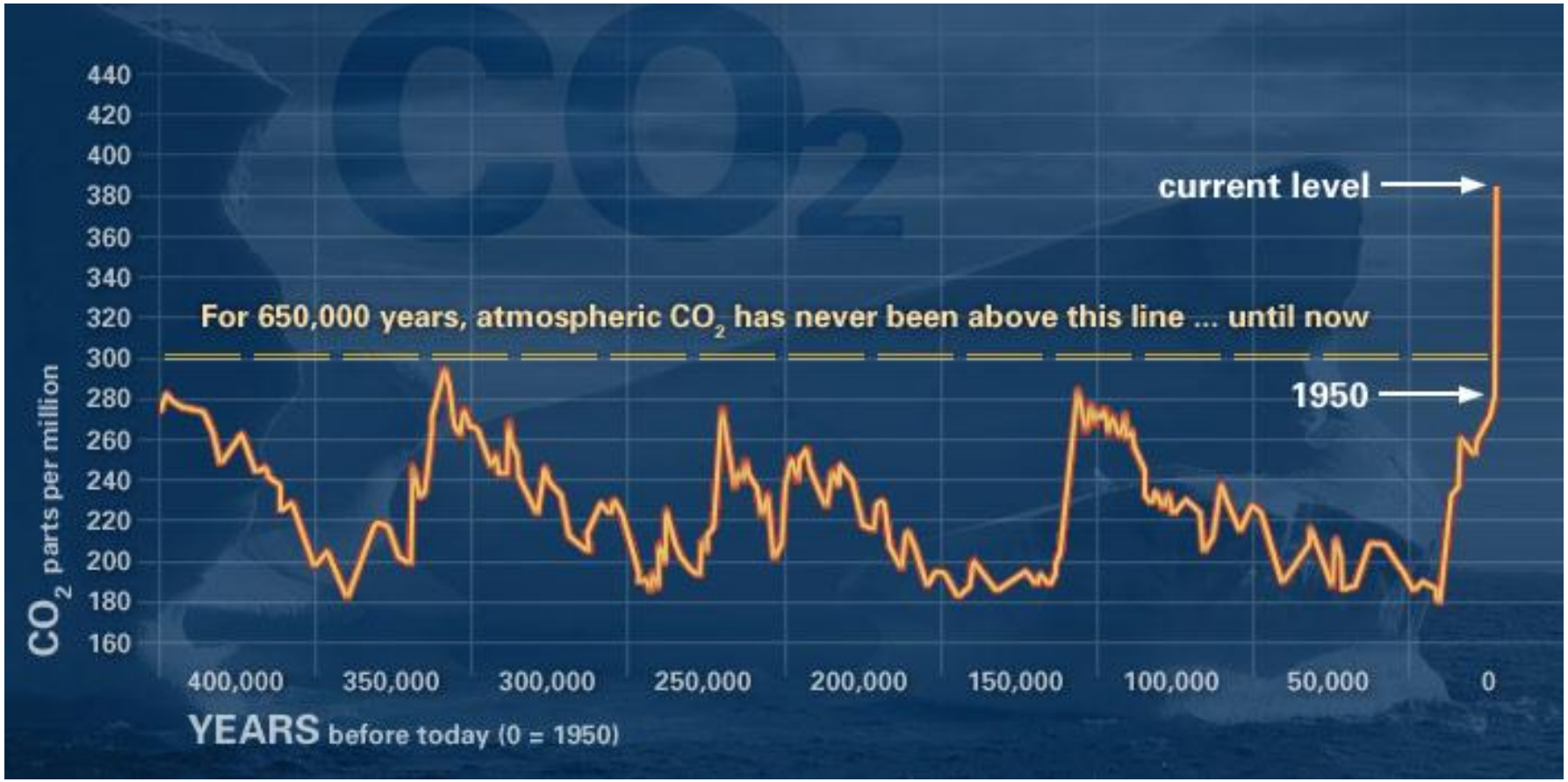
Energy, stability and security



Center for preventive action, US Council on Foreign Relations

Energy and the environment

Emissions and climate change



Carbon concentration always changes over time…

…but never at the rate and to the levels that we have seen over the past 50 years

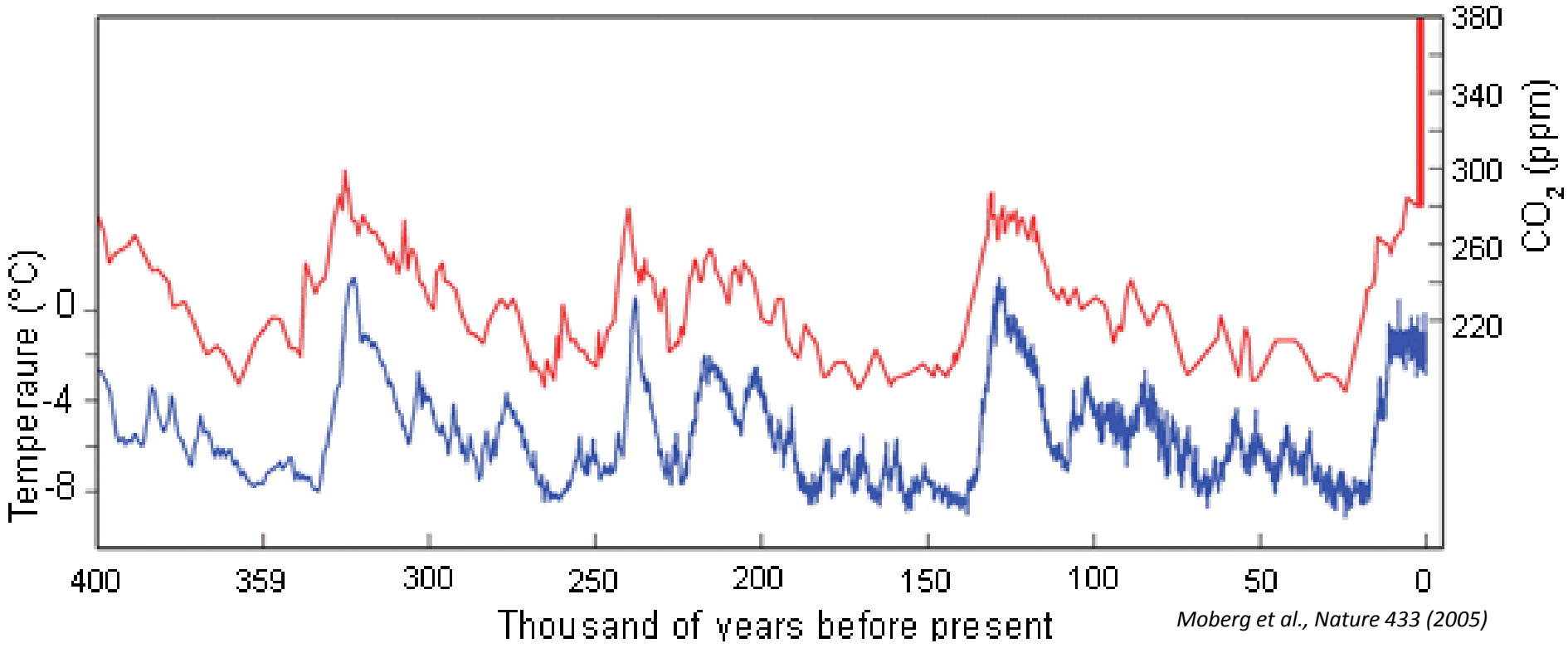
Energy and the environment

Emissions and climate change

Carbon emissions are antropogenic

Energy and the environment

Emissions and climate change

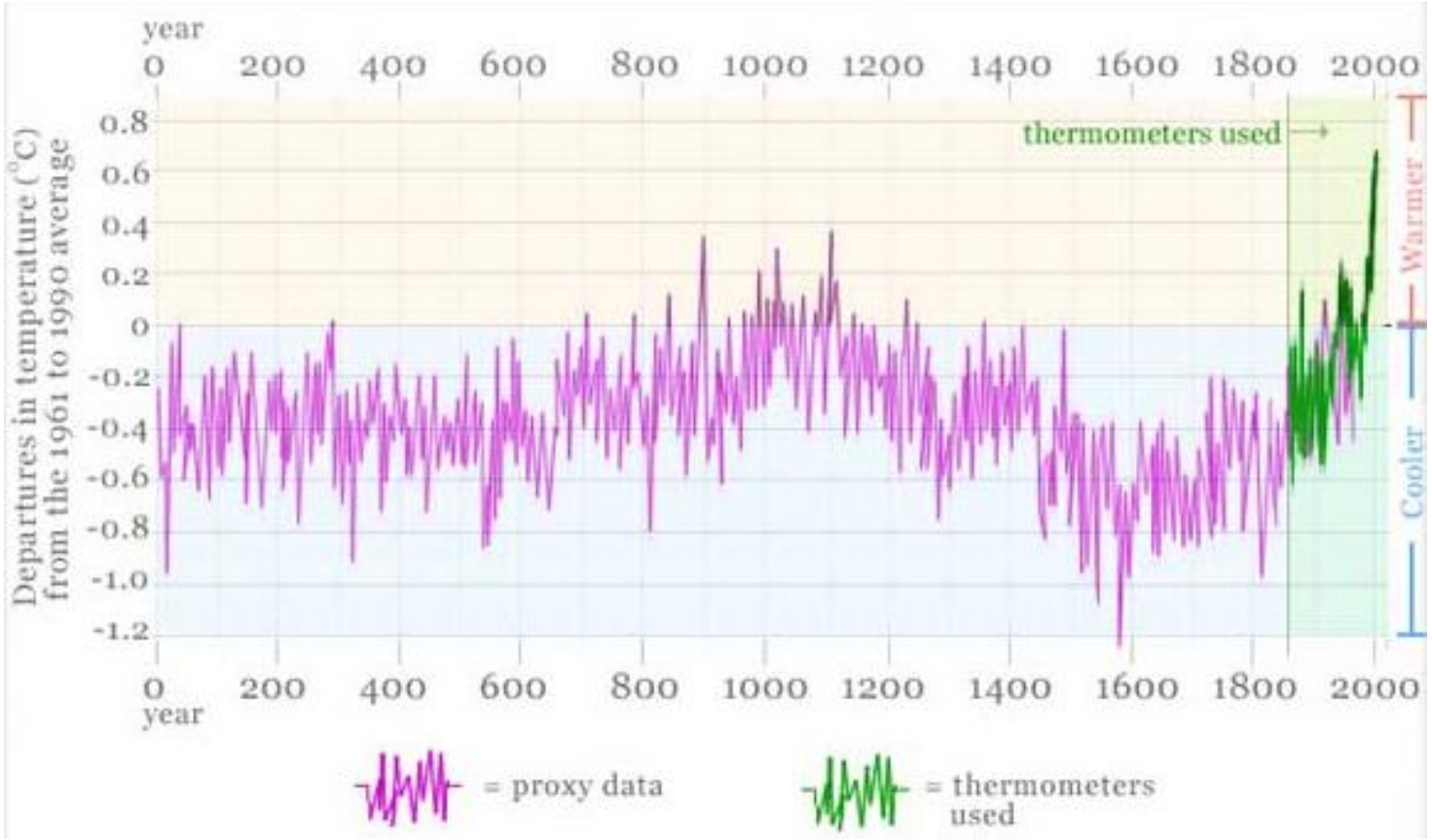


Moberg et al., Nature 433 (2005)

Carbon concentration and temperature are correlated

Energy and the environment

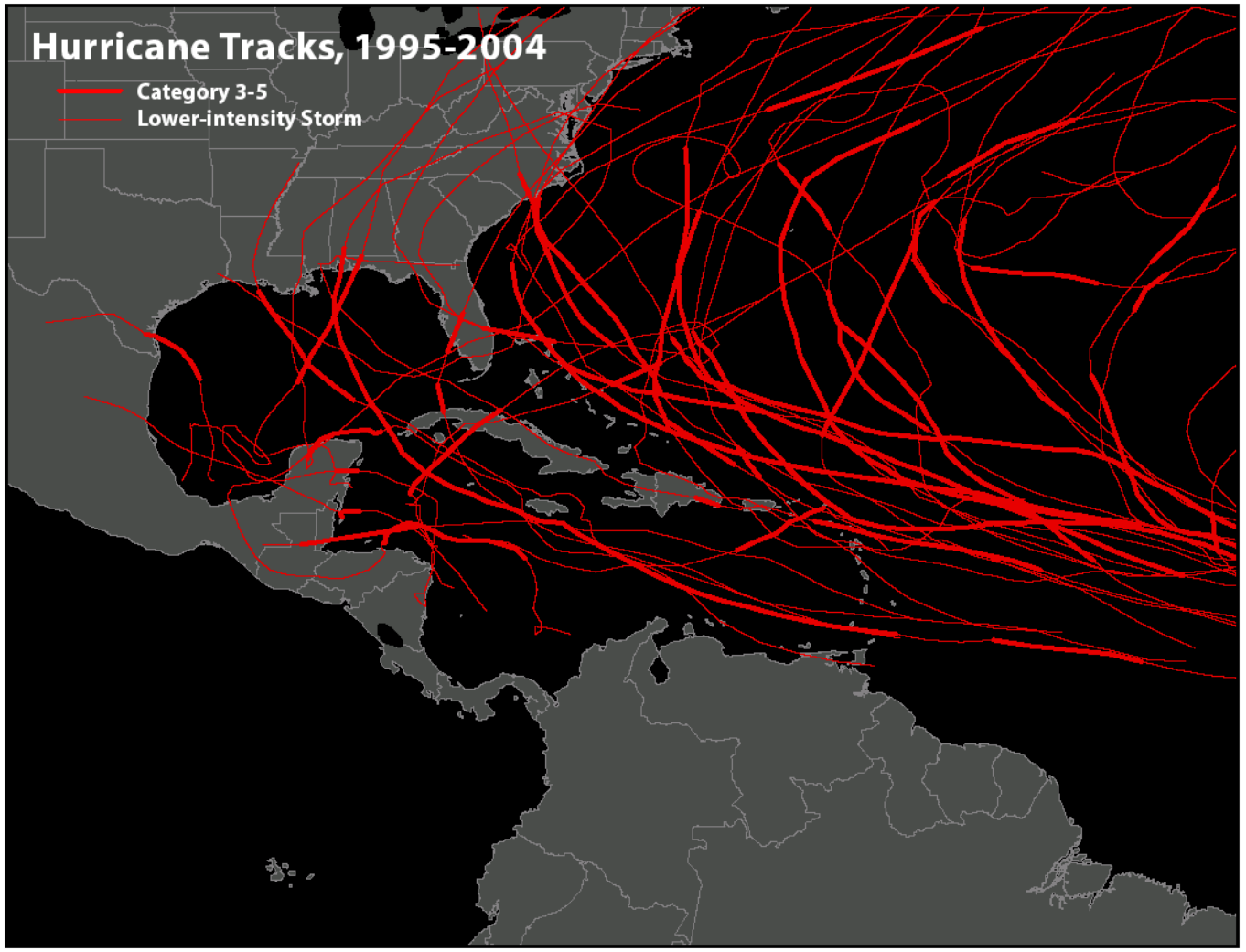
Emissions and climate change



Temperature seems to be raising

Energy and the environment

Emissions and climate change



Energy and the environment

Emissions and climate change

Energy, Environment, and Economy

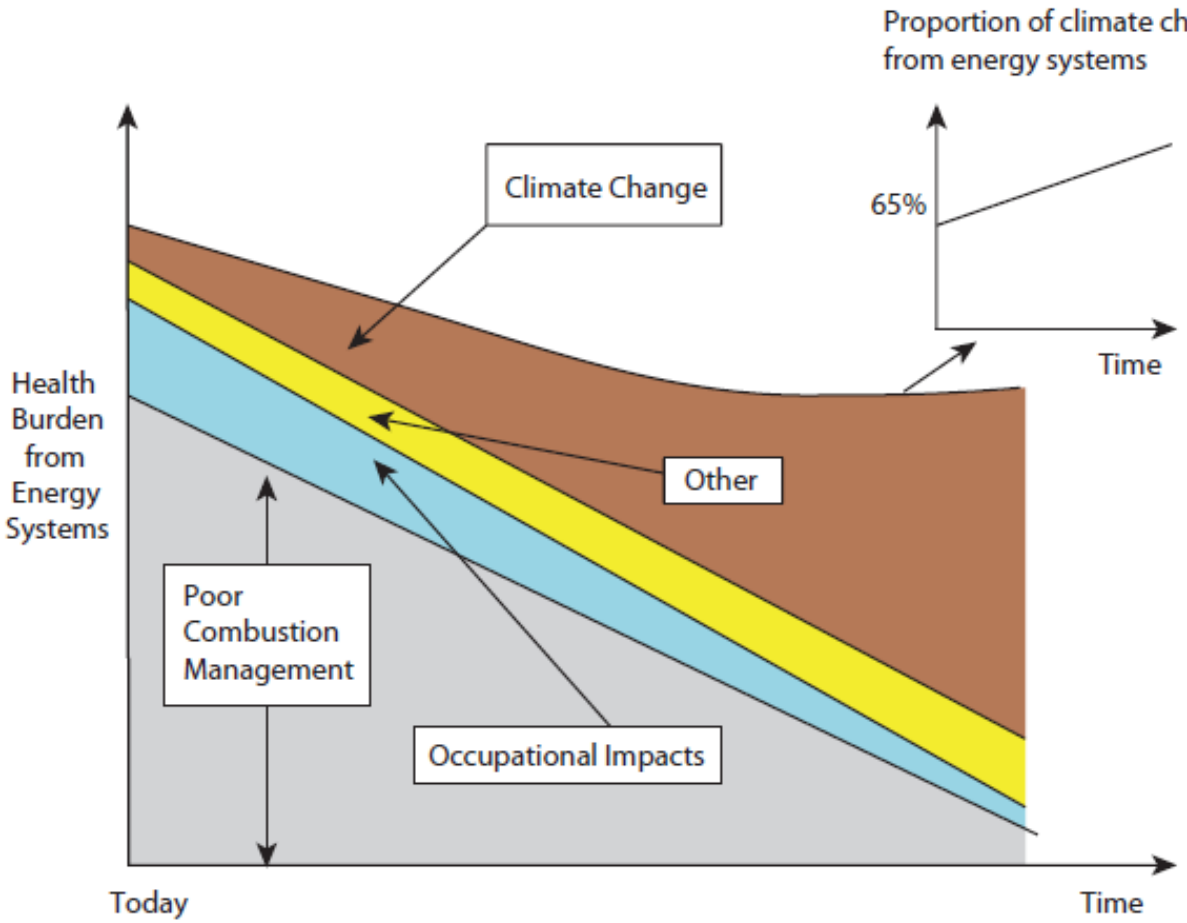
la Repubblica.it

AMBIENTE

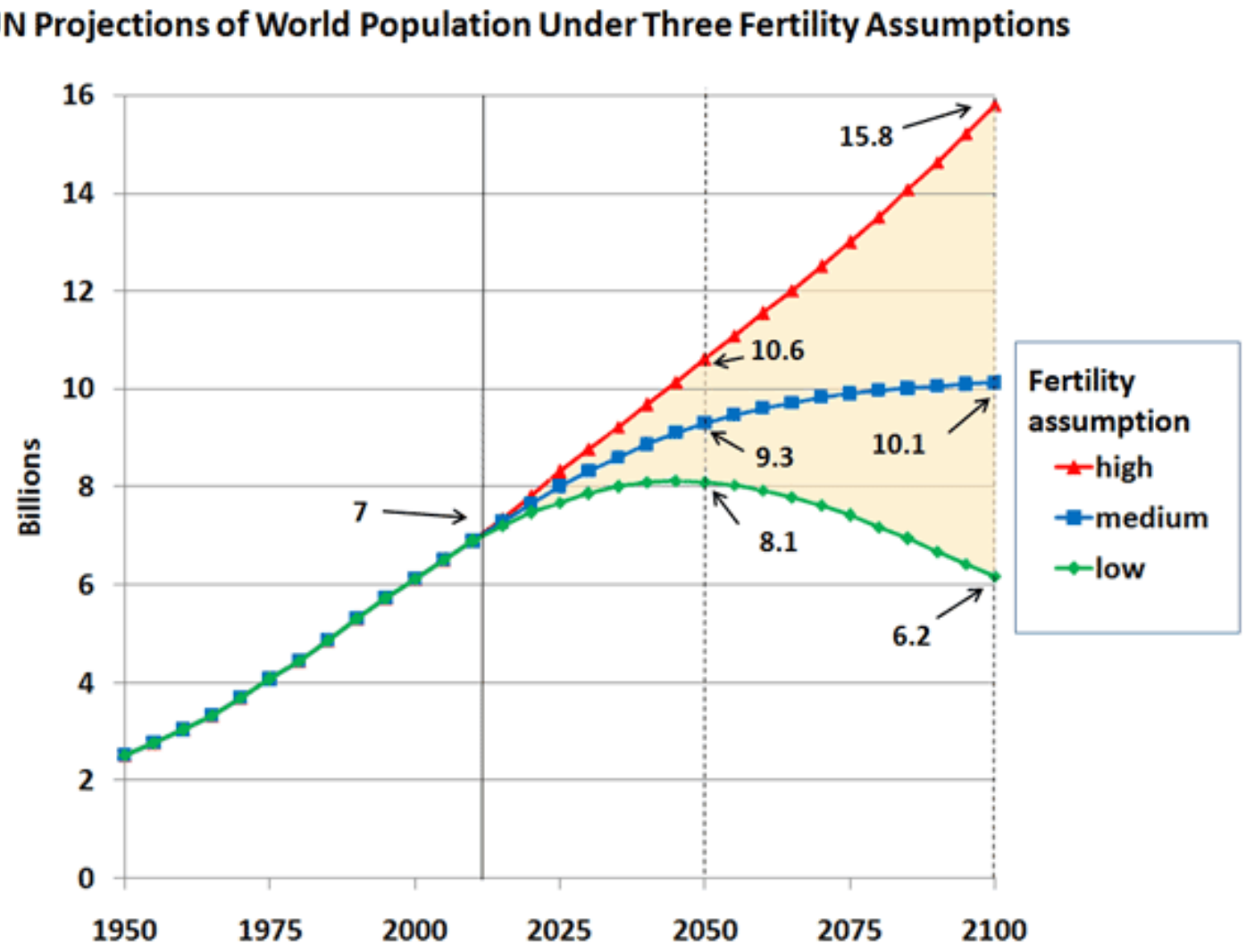
Entro gennaio convocati gli esperti che hanno preparato la ricerca per la Ue
Nel conto i danni a turismo e agricoltura e le sanzioni per le violazioni di Kyoto

Clima, minaccia per l'economia l'Italia rischia decine di miliardi

Energy and Health



Energy and Population



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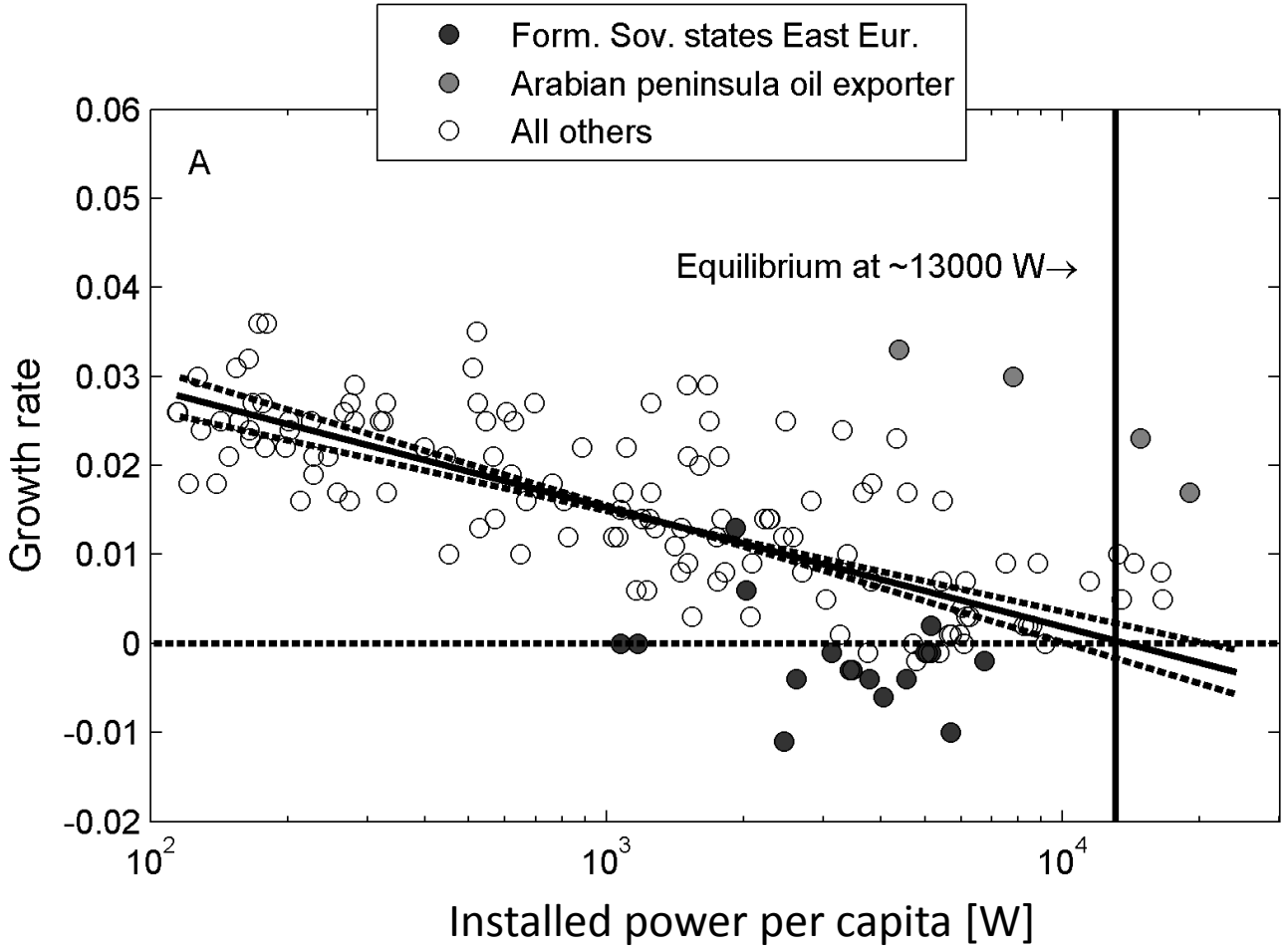
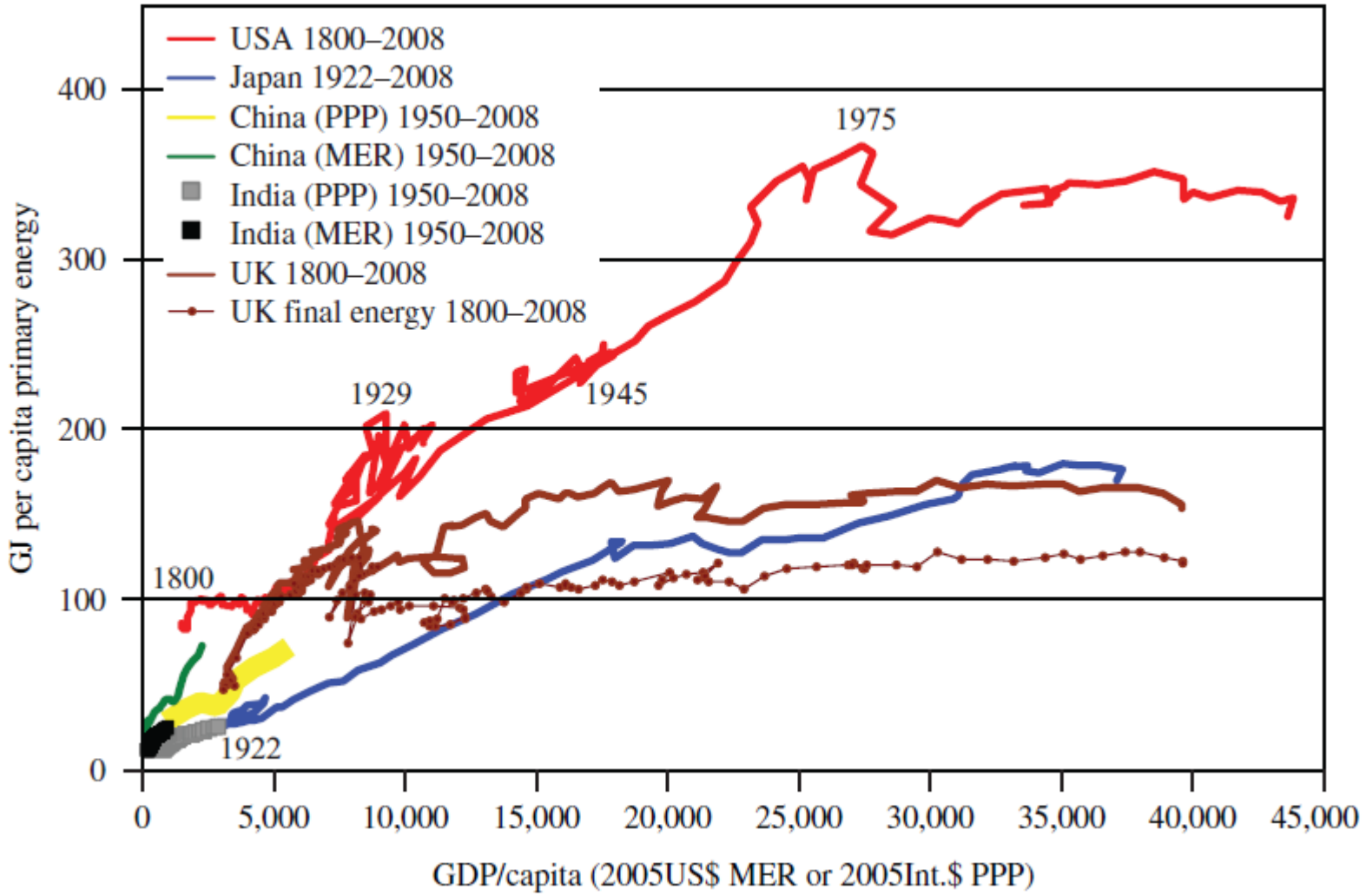


Energy might not be sufficient to sustain stabilization of the population

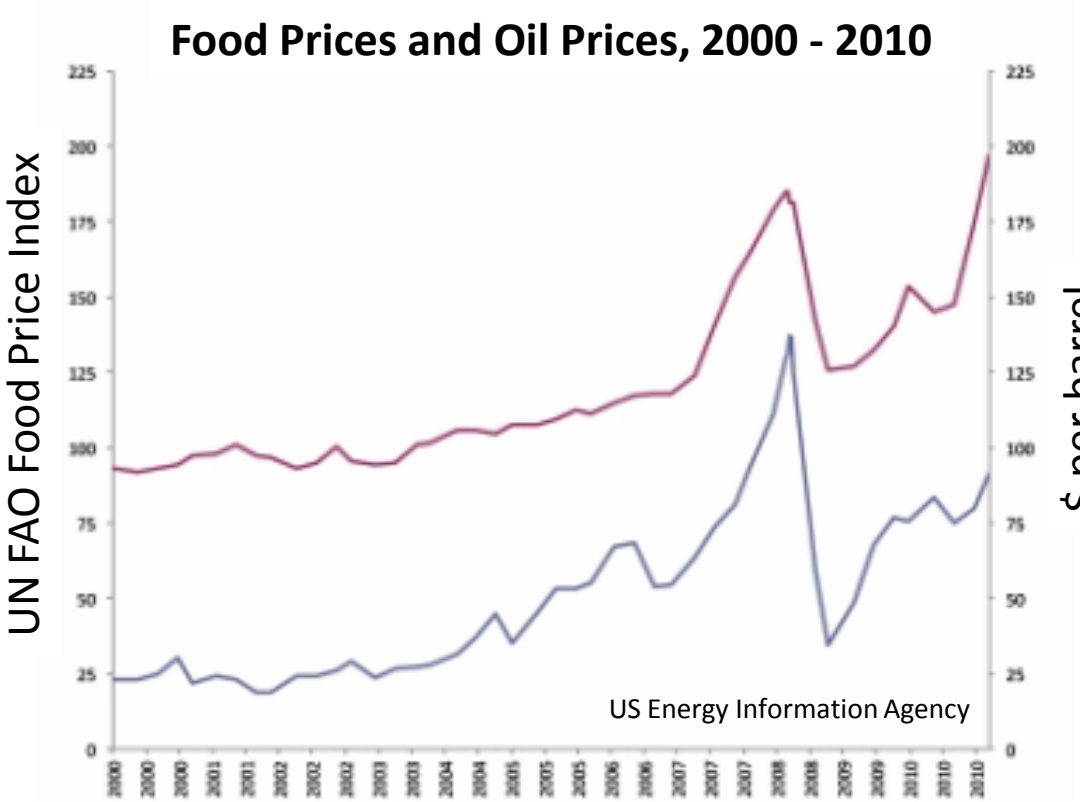
DeLong JP et al, PLoS ONE 5, e13206 (2010)

Energy and Economy



Energy and Food

- Food vs Energy dilemma
  (food cropland substituted by energy crops)
- Link between prices of food and prices of energy



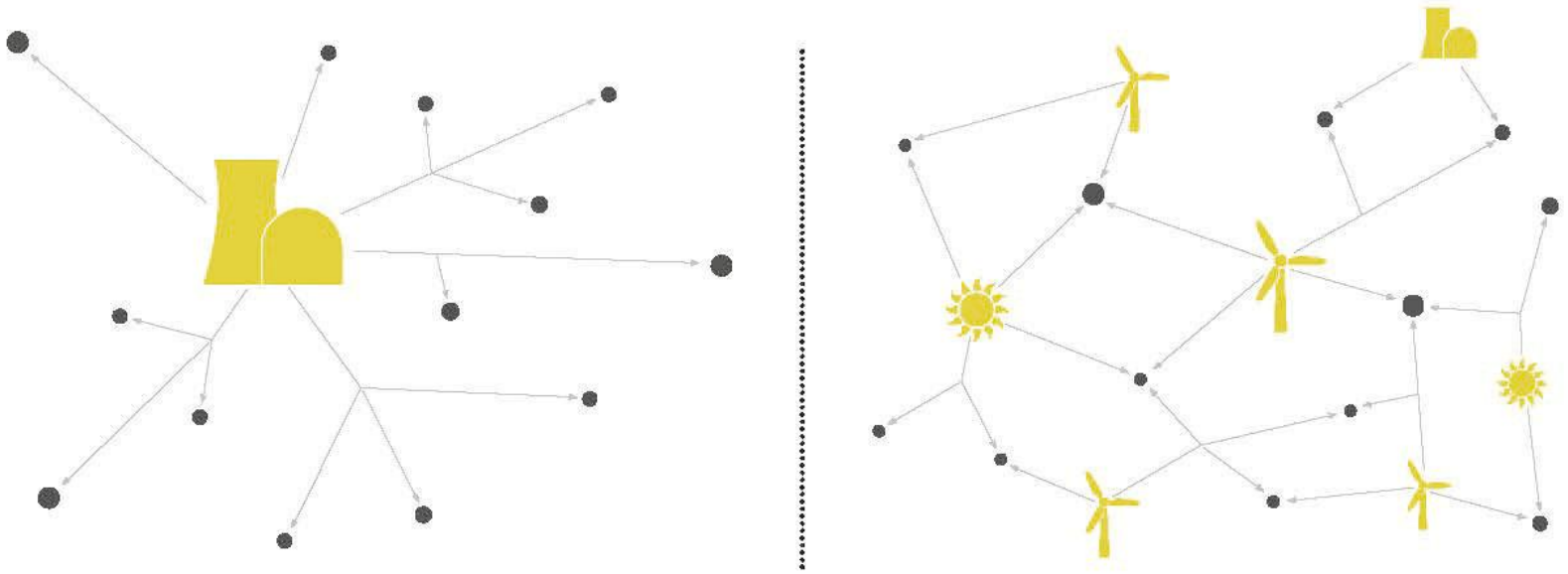
Energy: A global issue - complexity

Energy and complexity

- a different standpoint -

Complexity arising from **large number of players** and strong **interconnectedness**

E.g.: Integration of different energy sources
Smart grid



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  - Many new players
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Energy Supply Chain: Examples

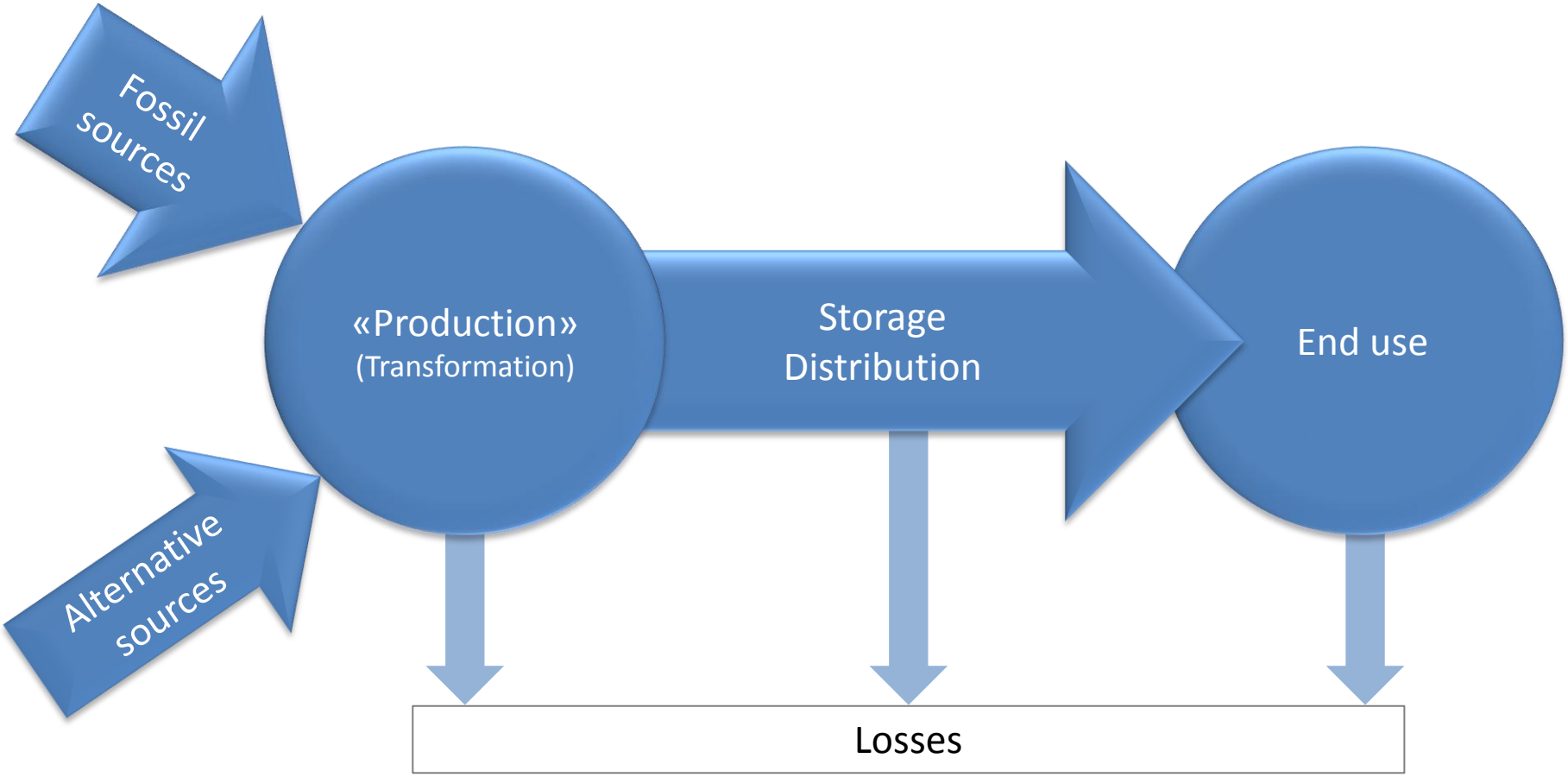




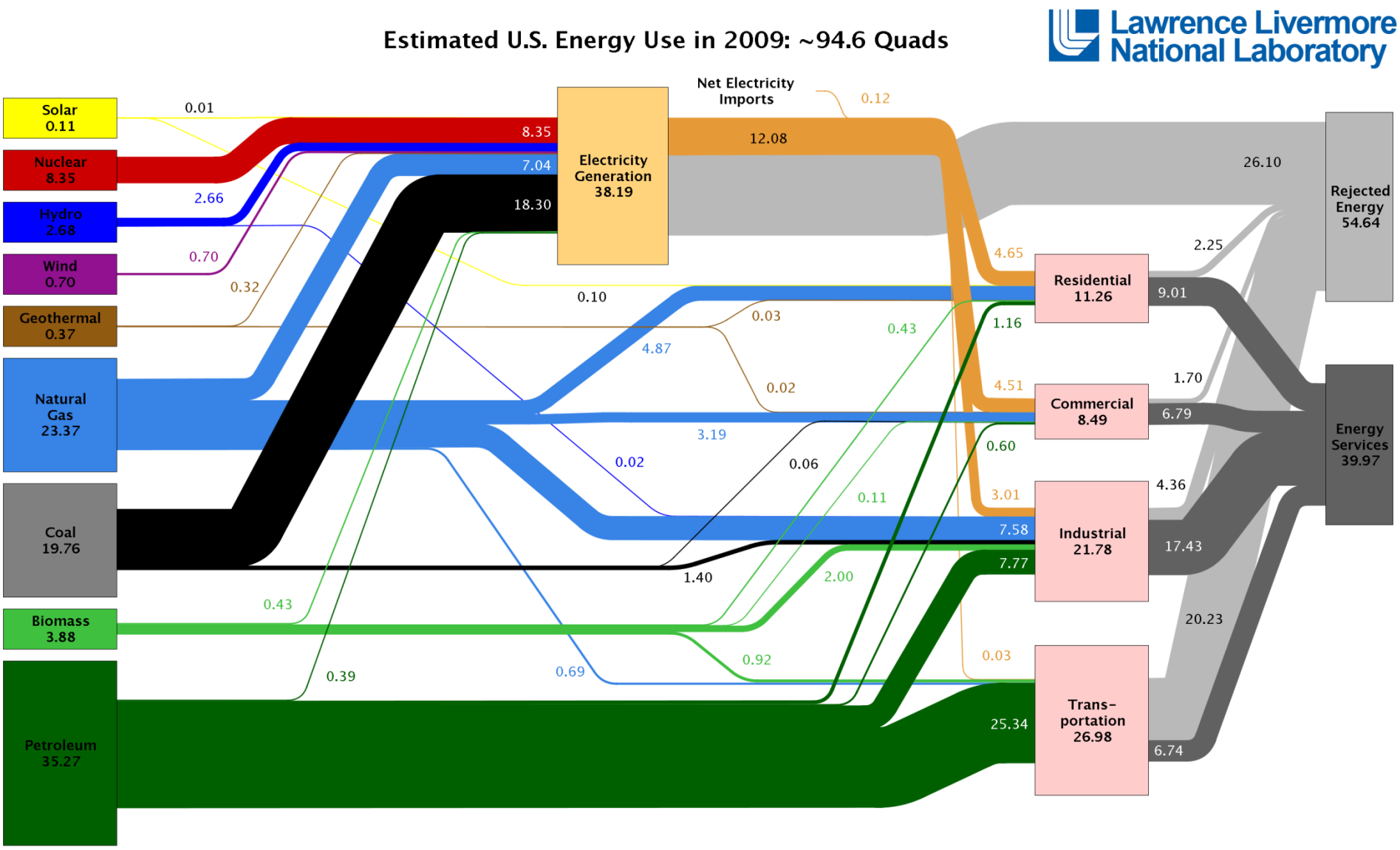




Energy Supply Chain

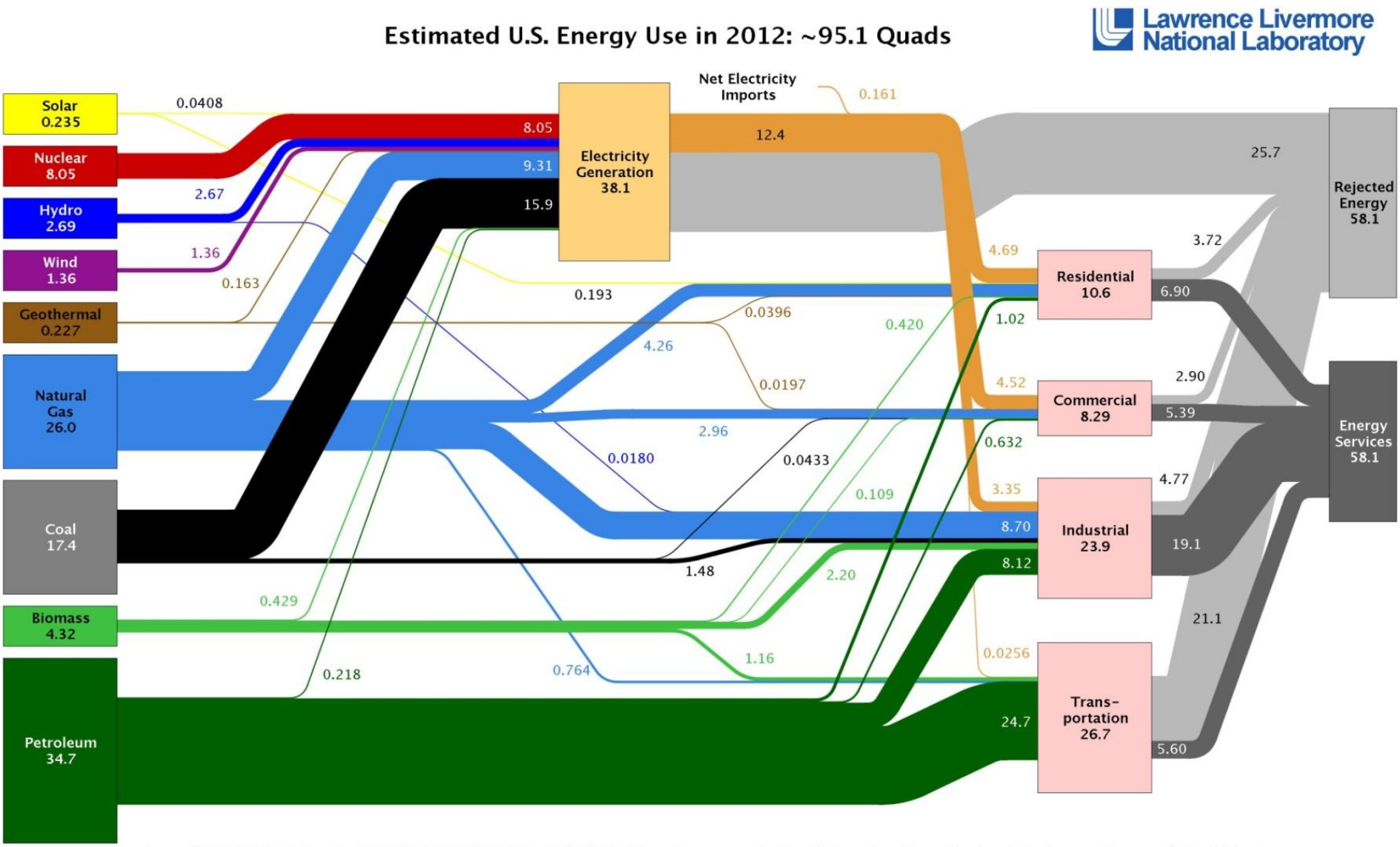


Complexity of the Energy Supply Chain



Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Complexity of the Energy Supply Chain



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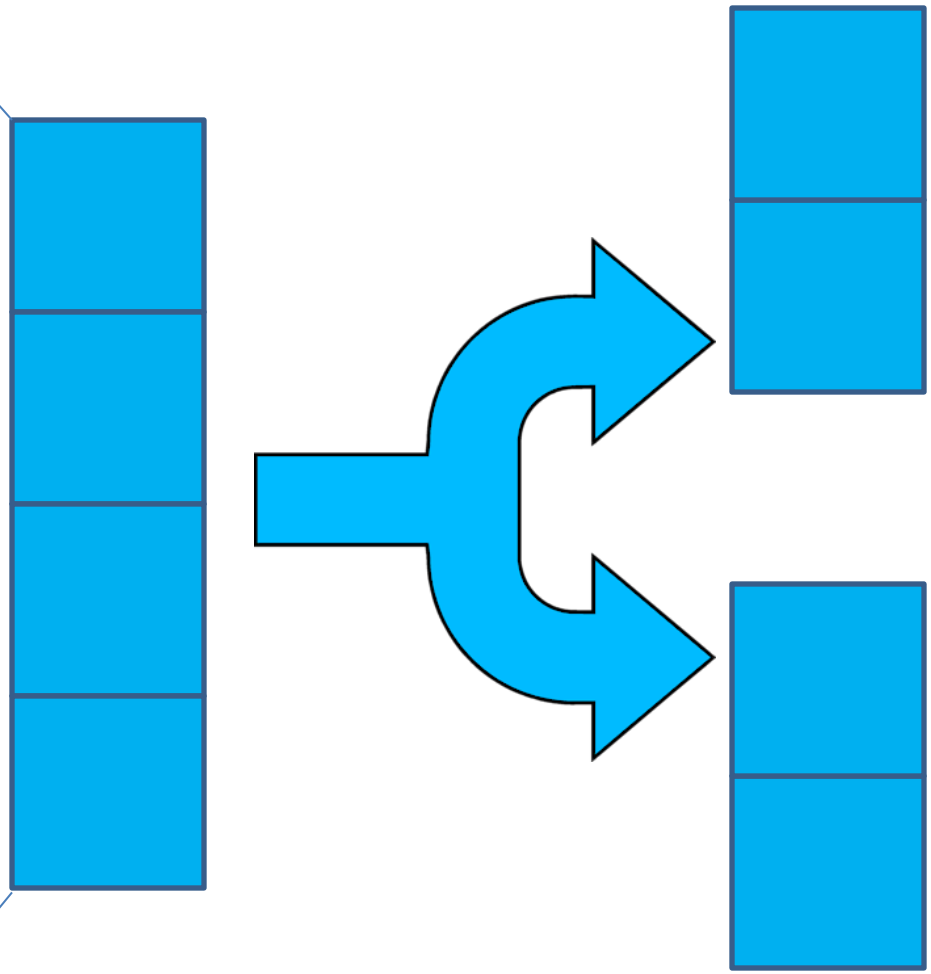
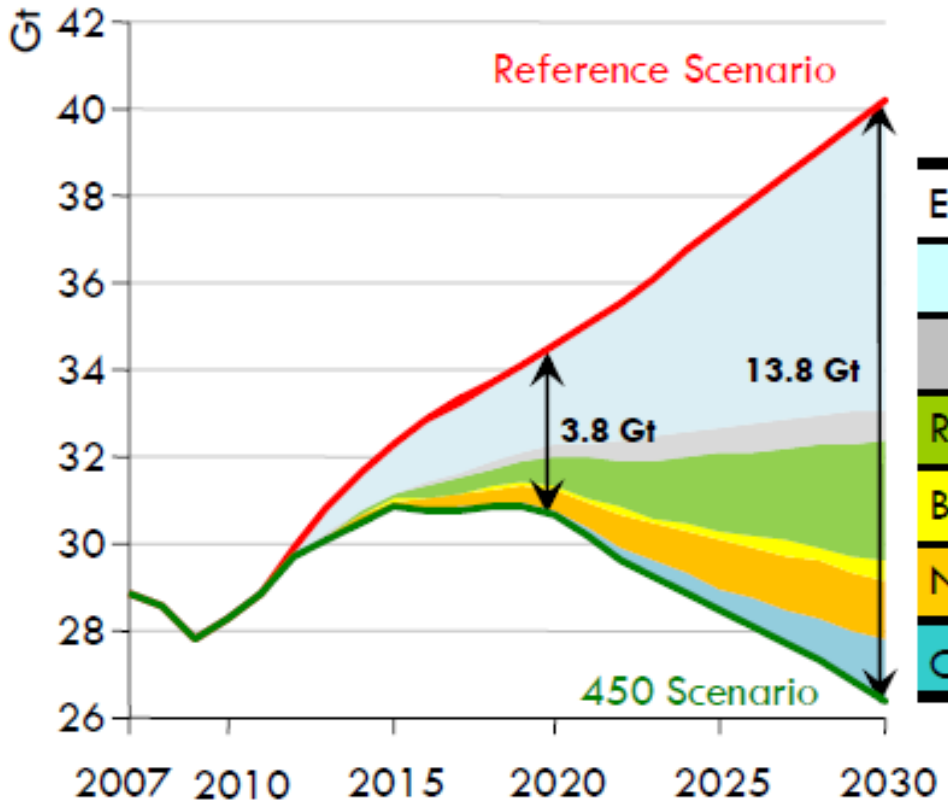
End-of-chain energy efficiency and saving

The value more than doubles!



Role of efficiency

for a carbon-free energy system



Share of abatement (%)

	2020	2030
Efficiency	65	57
End-use	*59*	*52*
Power plants	*6*	*5*
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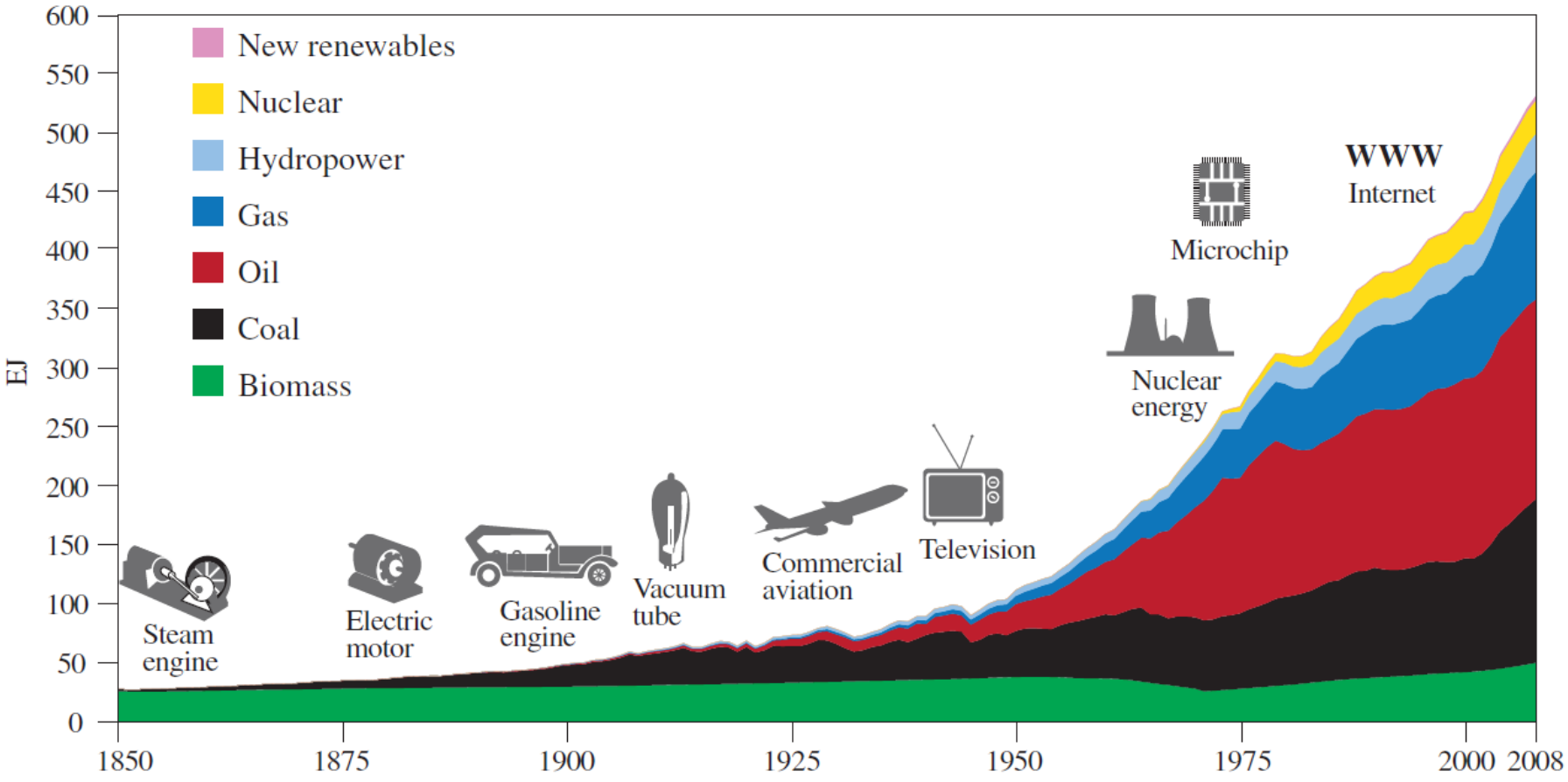
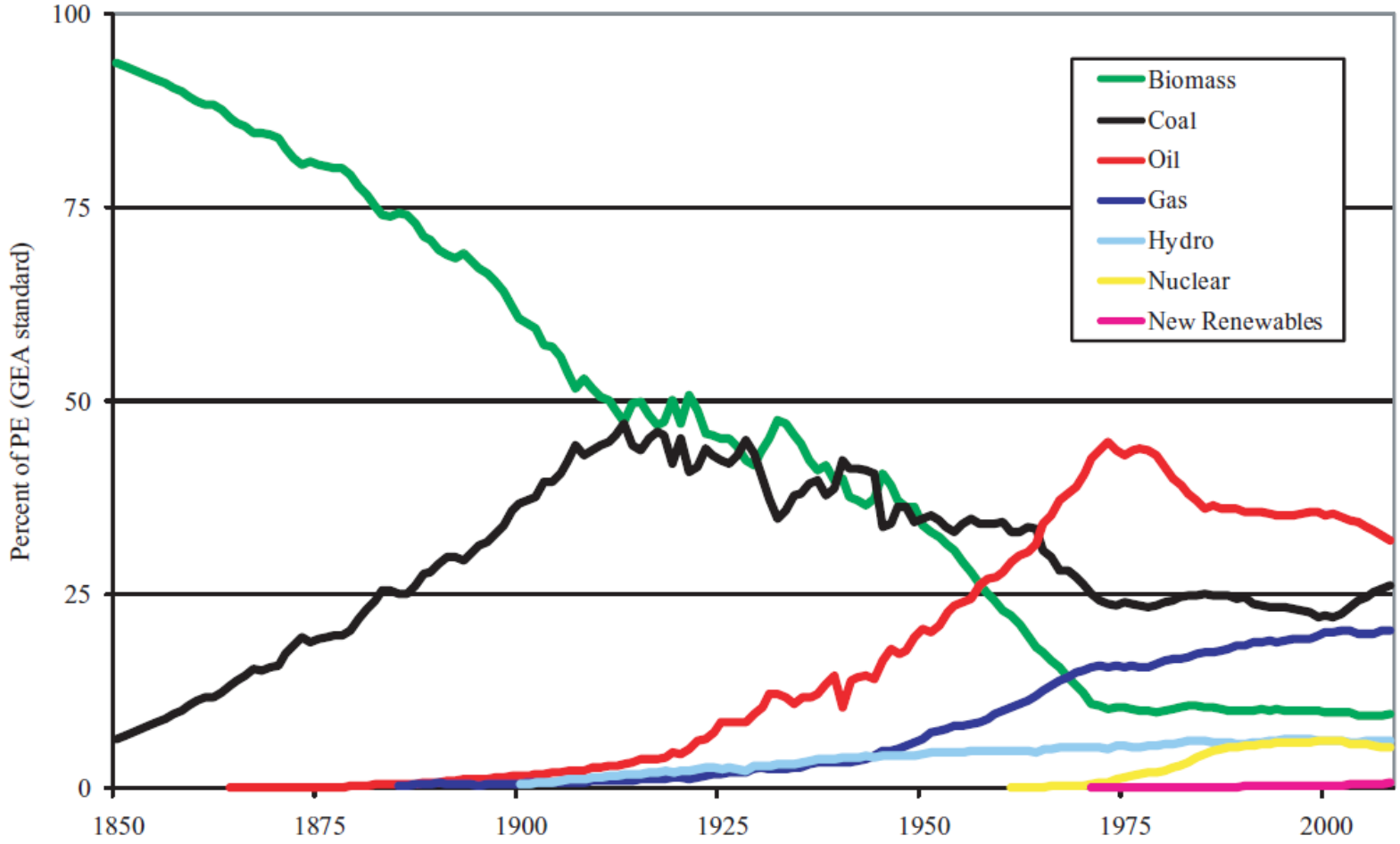
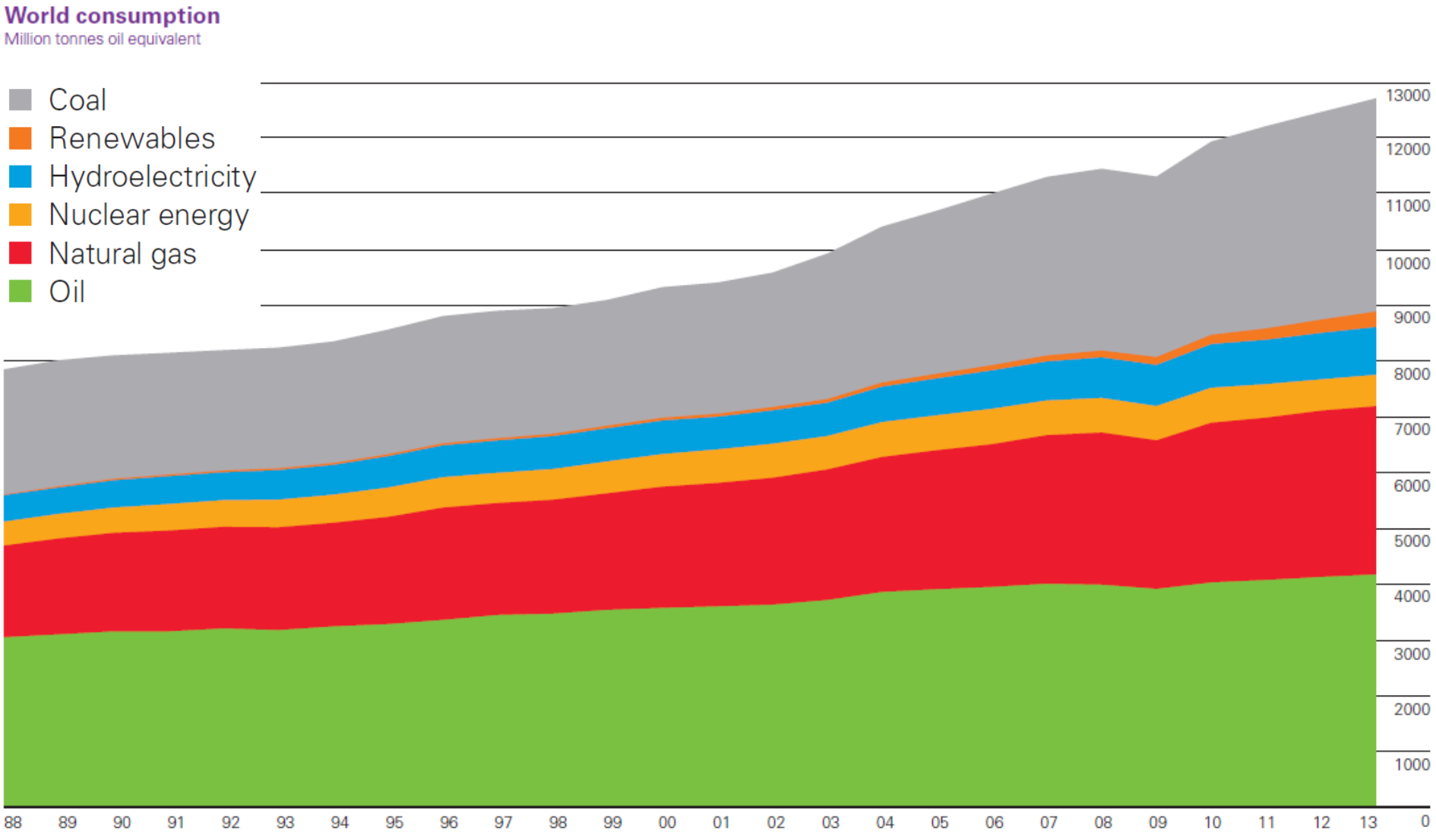
Energy demand growth



Energy Transitions

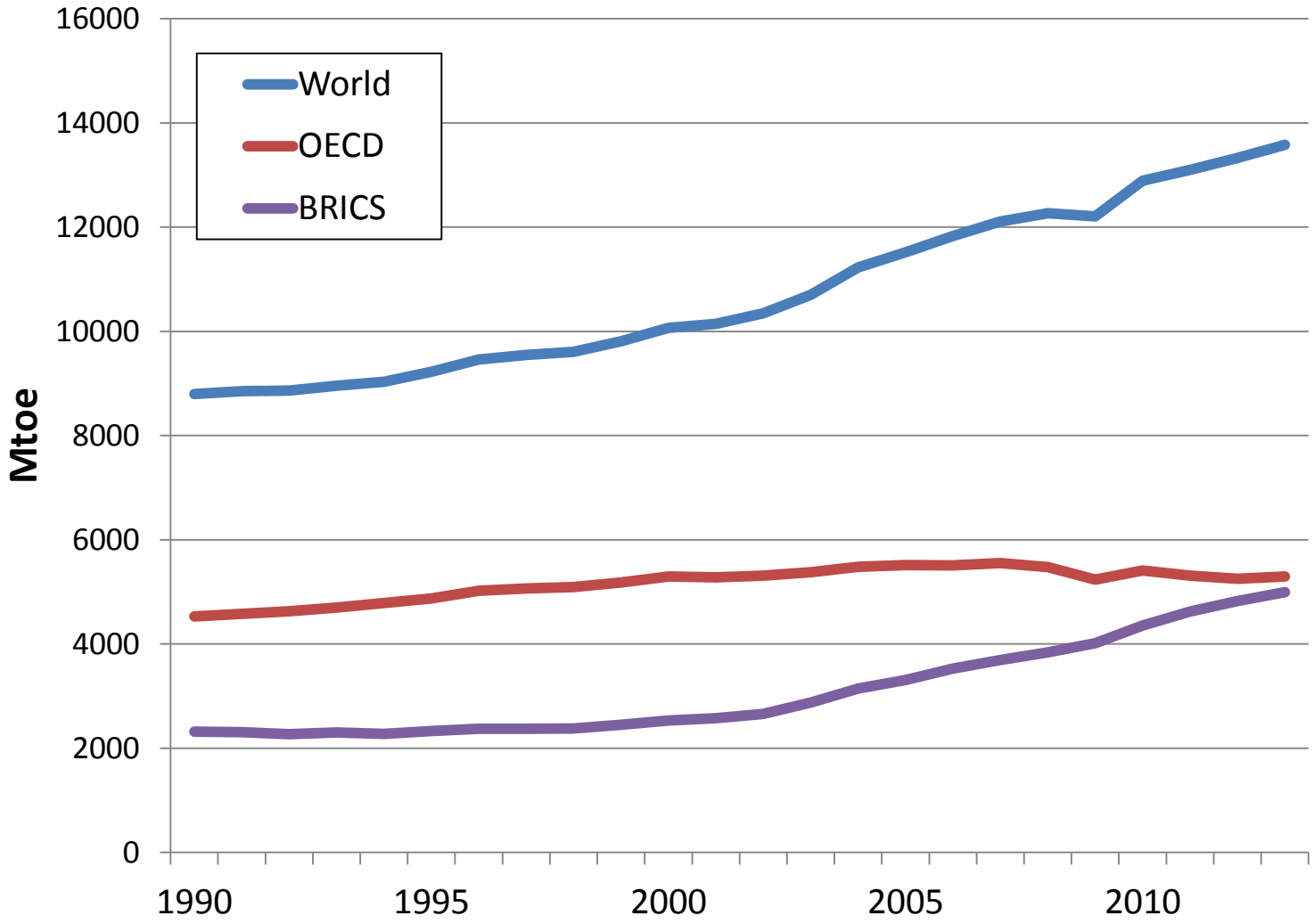


Global Energy Consumption



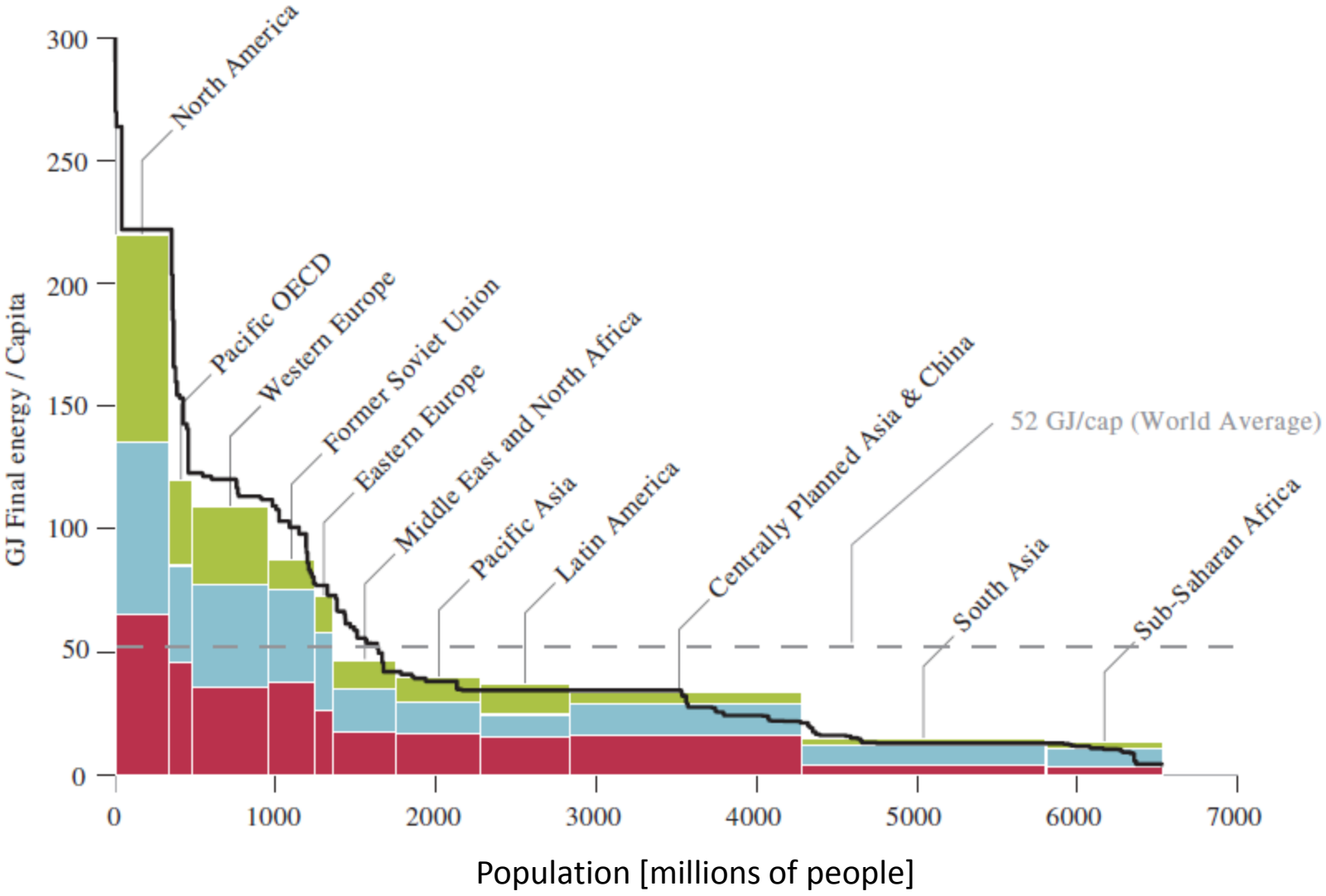
BP Statistical Review of World Energy – June 2014

Global Energy Consumption



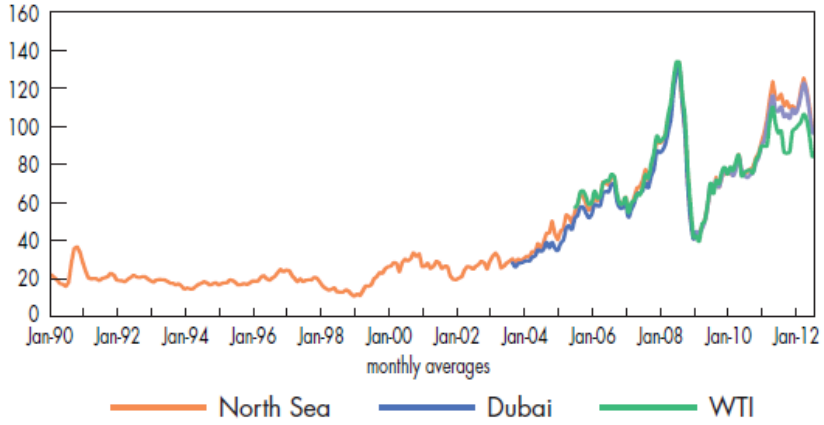
Enerdata – Global Energy Statistical Yearbook 2014

Energy demand: Global imbalance

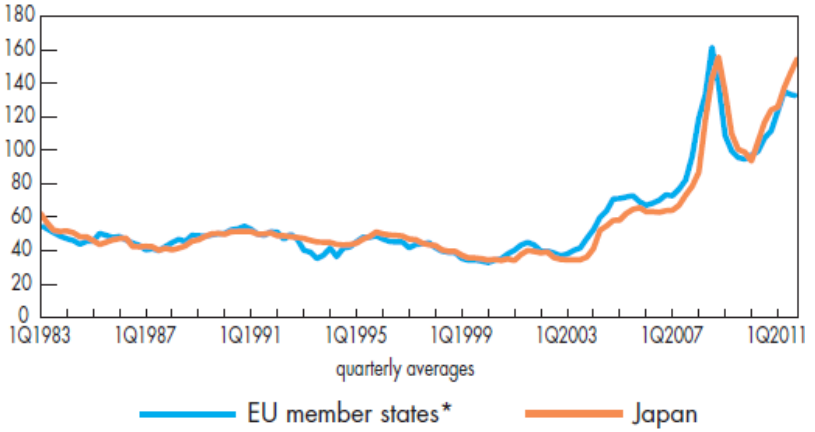


Price dynamics of primary energy sources

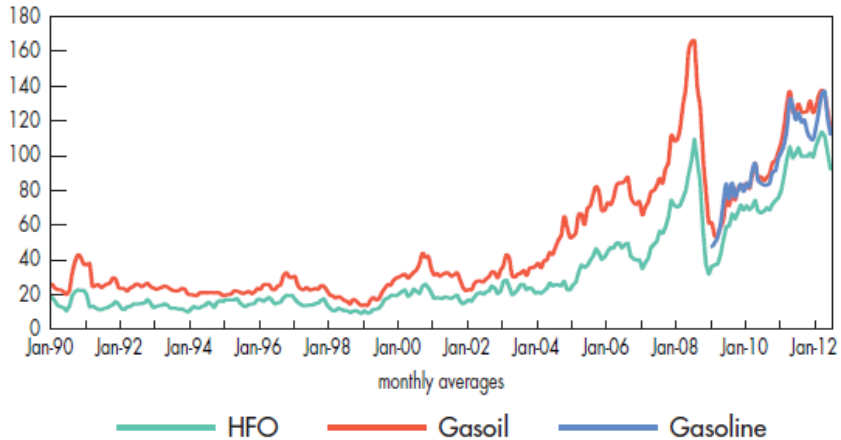
Key crude oil spot prices in USD/barrel



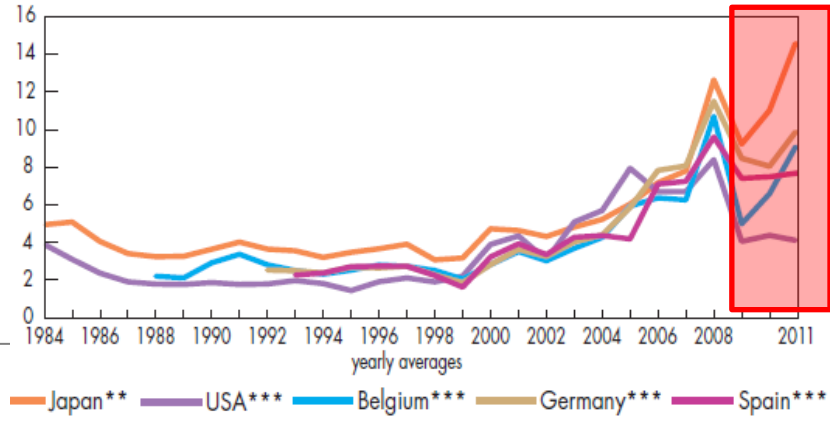
Steam coal import costs in USD/tonne



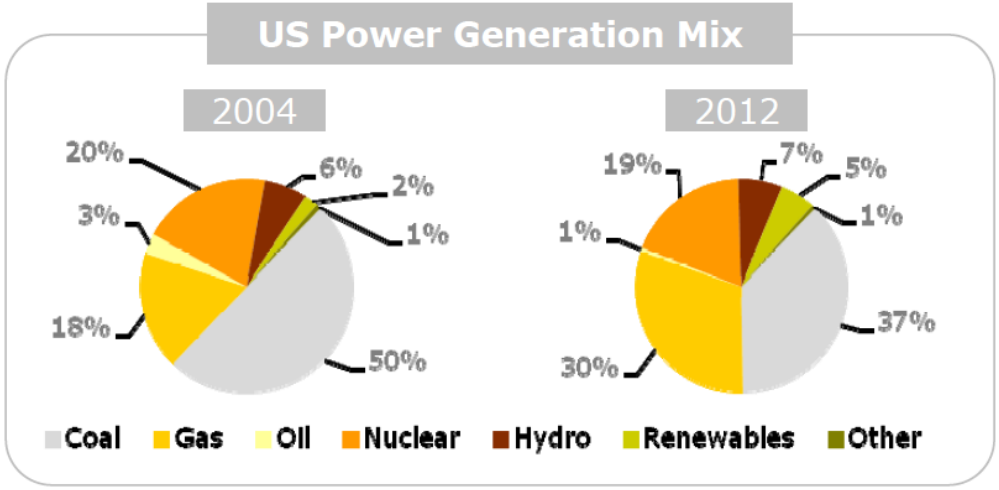
Rotterdam oil product spot prices in USD/barrel

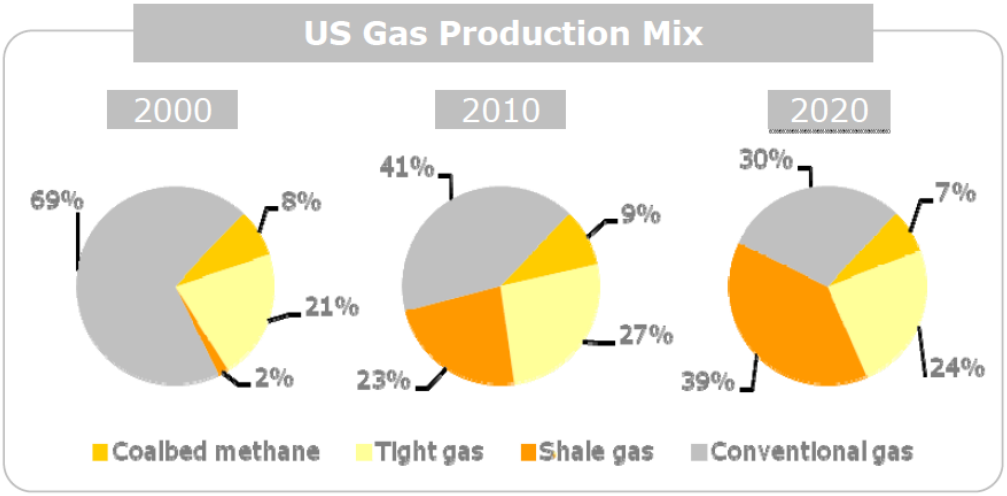


Natural gas import prices in USD/MBtu



Price dynamics: the effect of shale gas

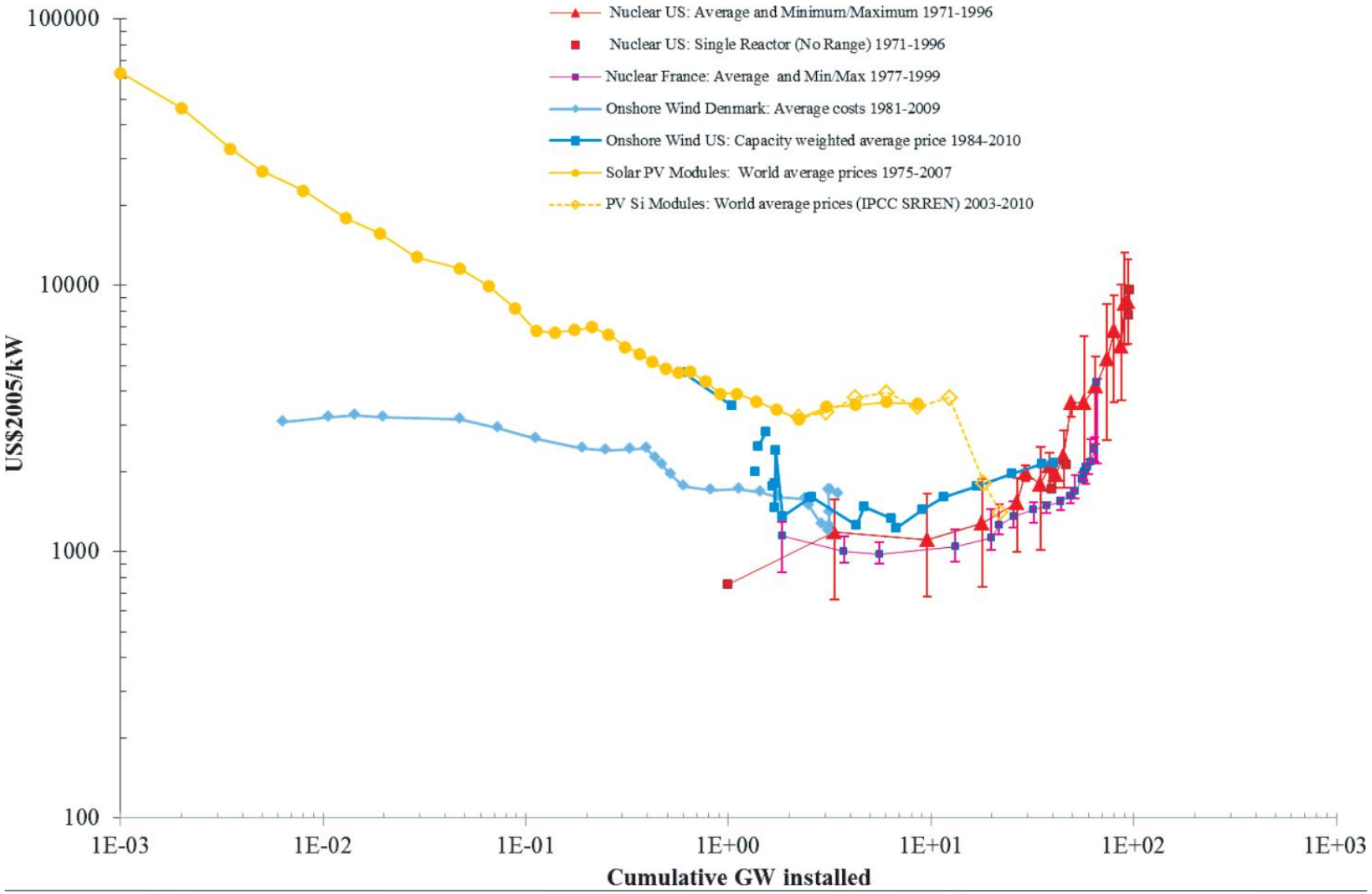




Trends in energy price indexes 2005-2012

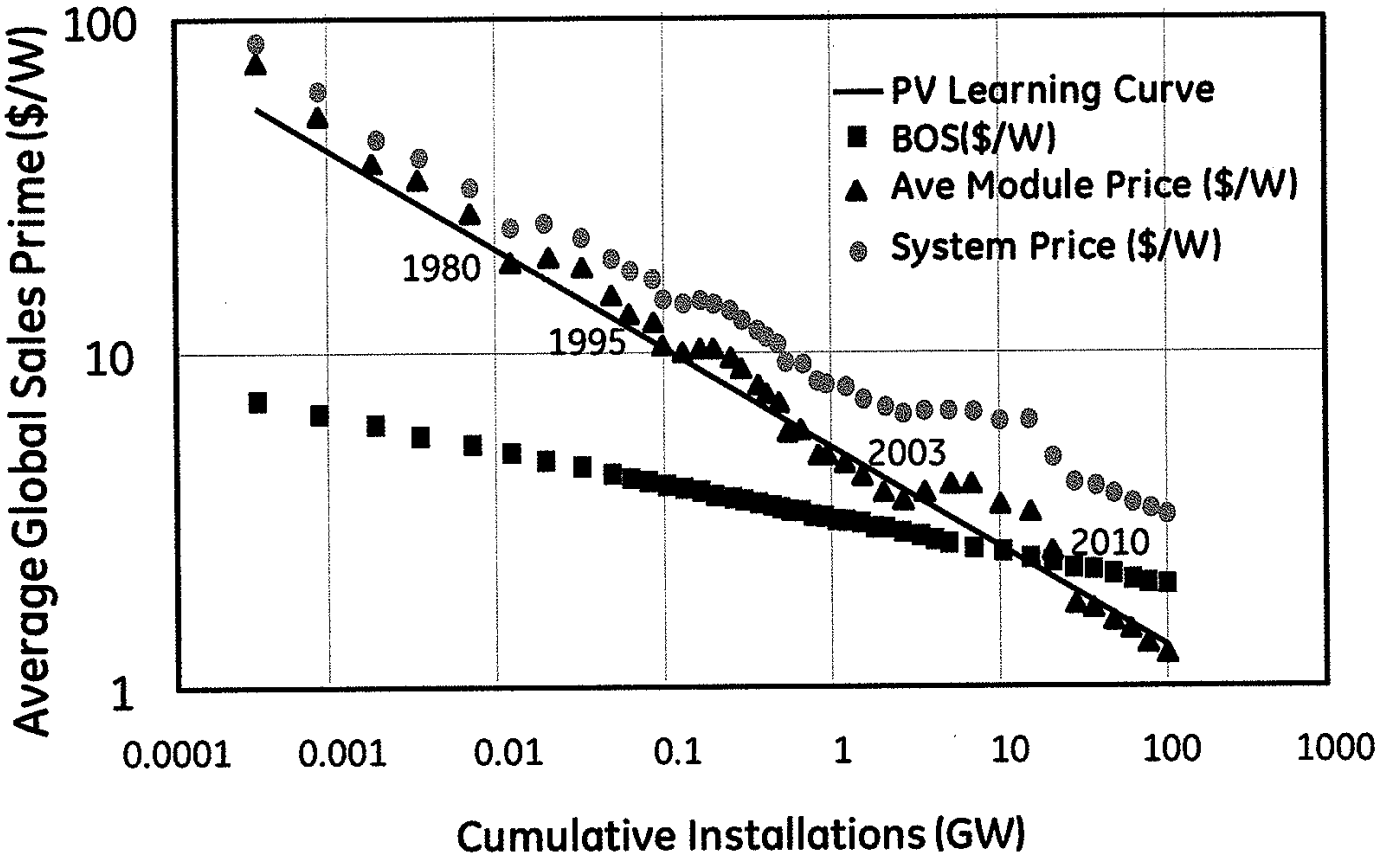
	EU	US
Gas price index Industry	35%	-66%
Gas price index Households	45%	3%
Electricity price index Industry	38%	-4%
Electricity price index Households	22%	8%

Price of energy from new sources



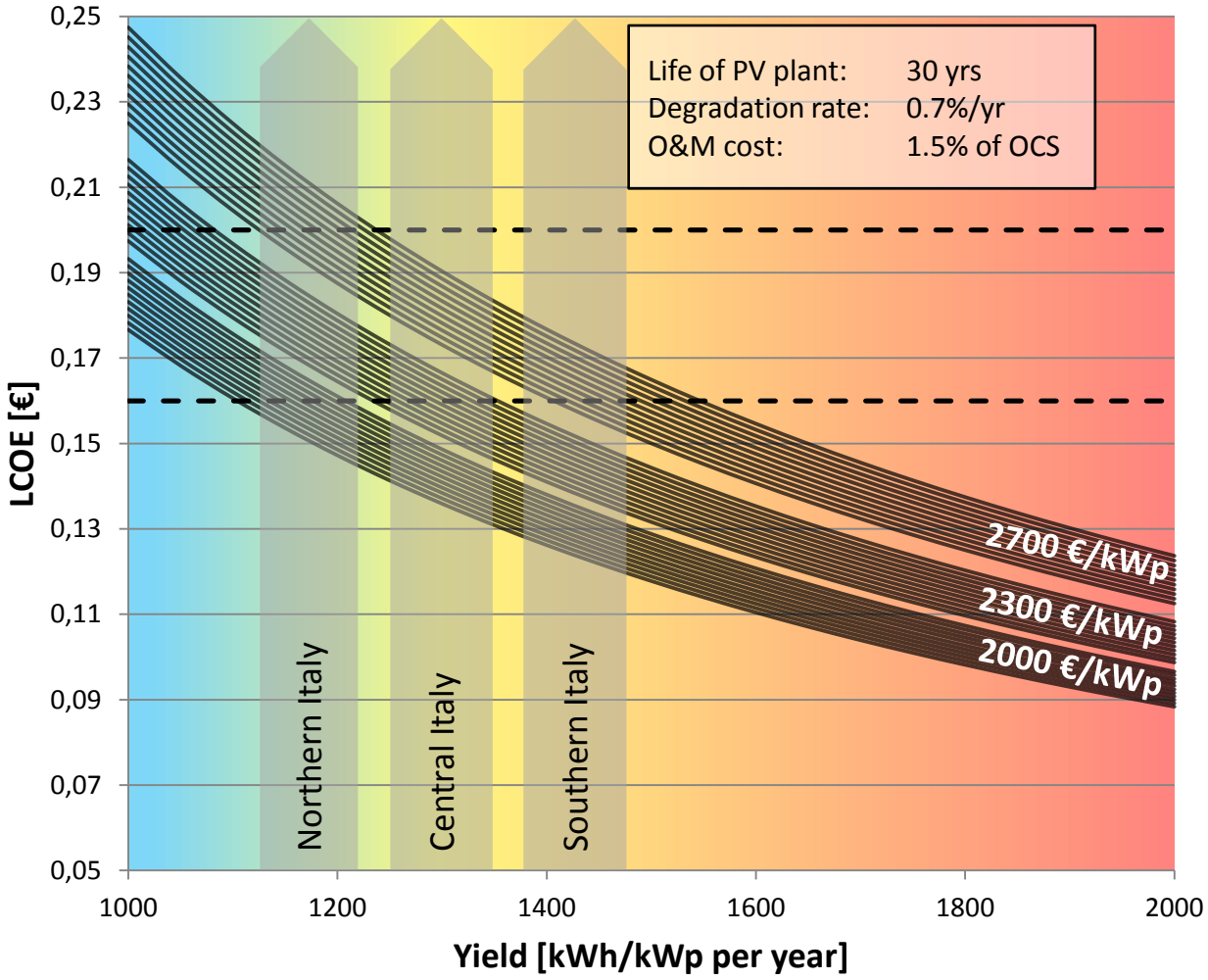
Price

Lessons learned from the photovoltaic technology



Price and Grid Parity

Lessons learned from the photovoltaic technology



Lughi and Pavan, ICCEP 2013

Price and Grid Parity

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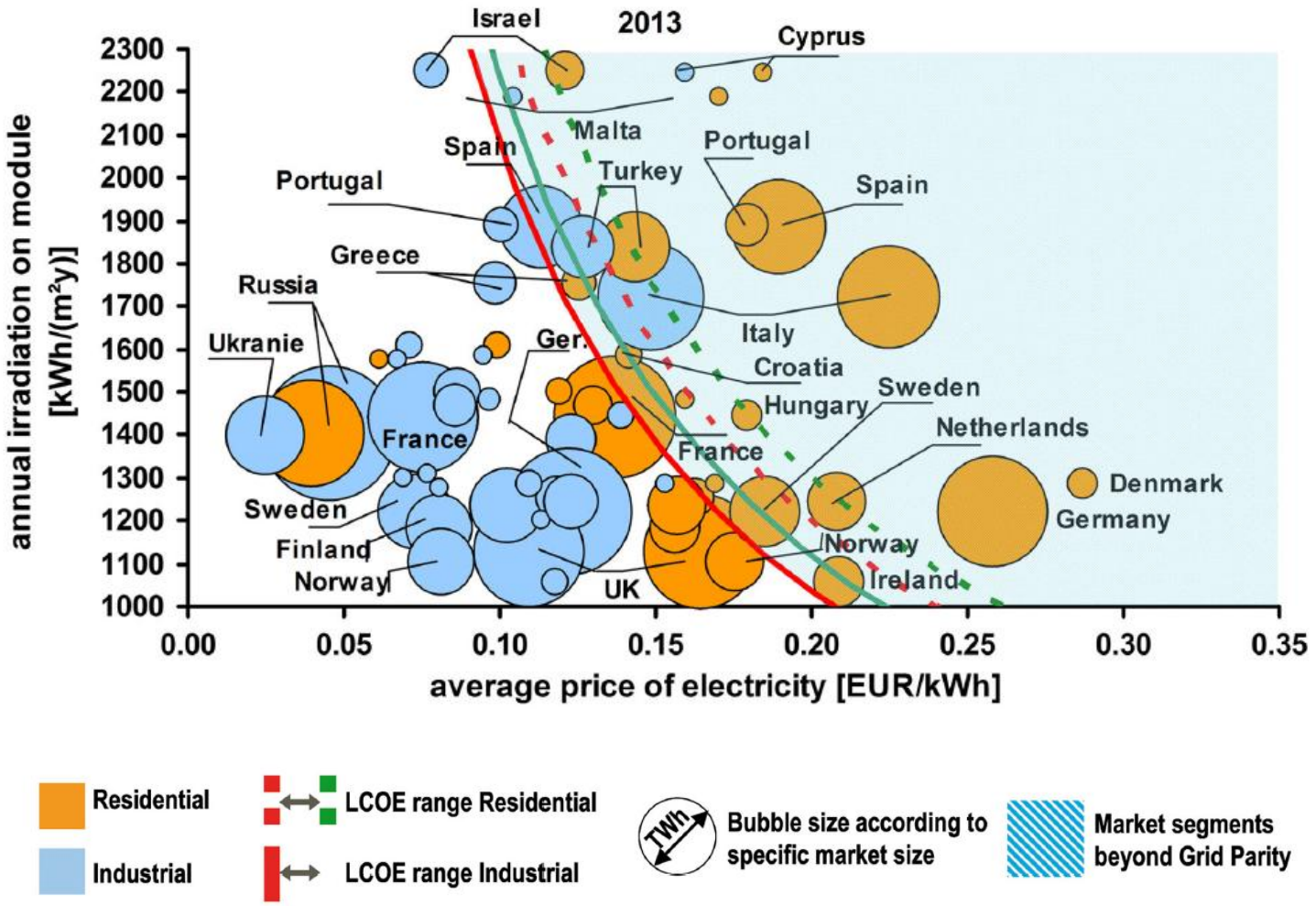
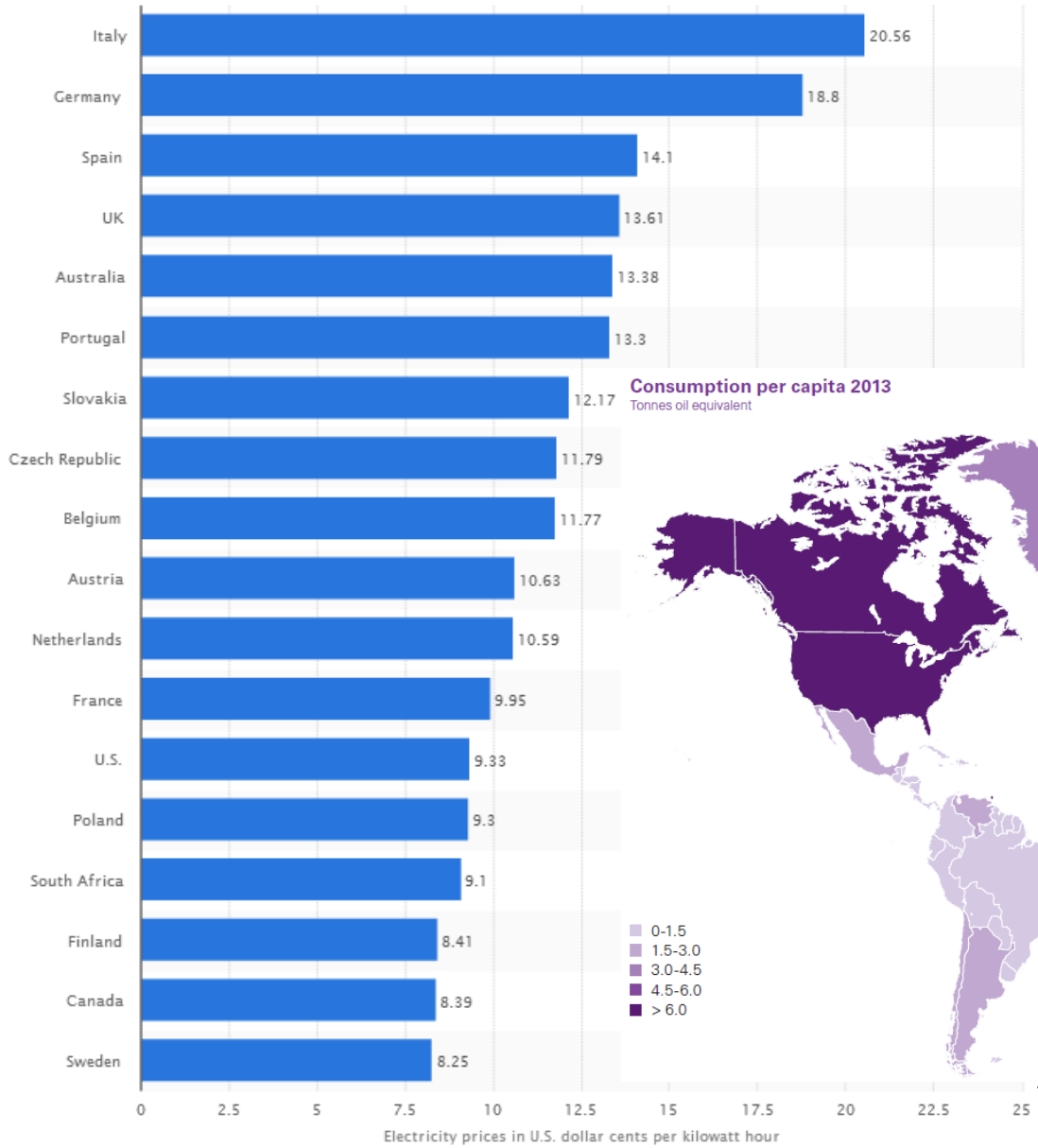
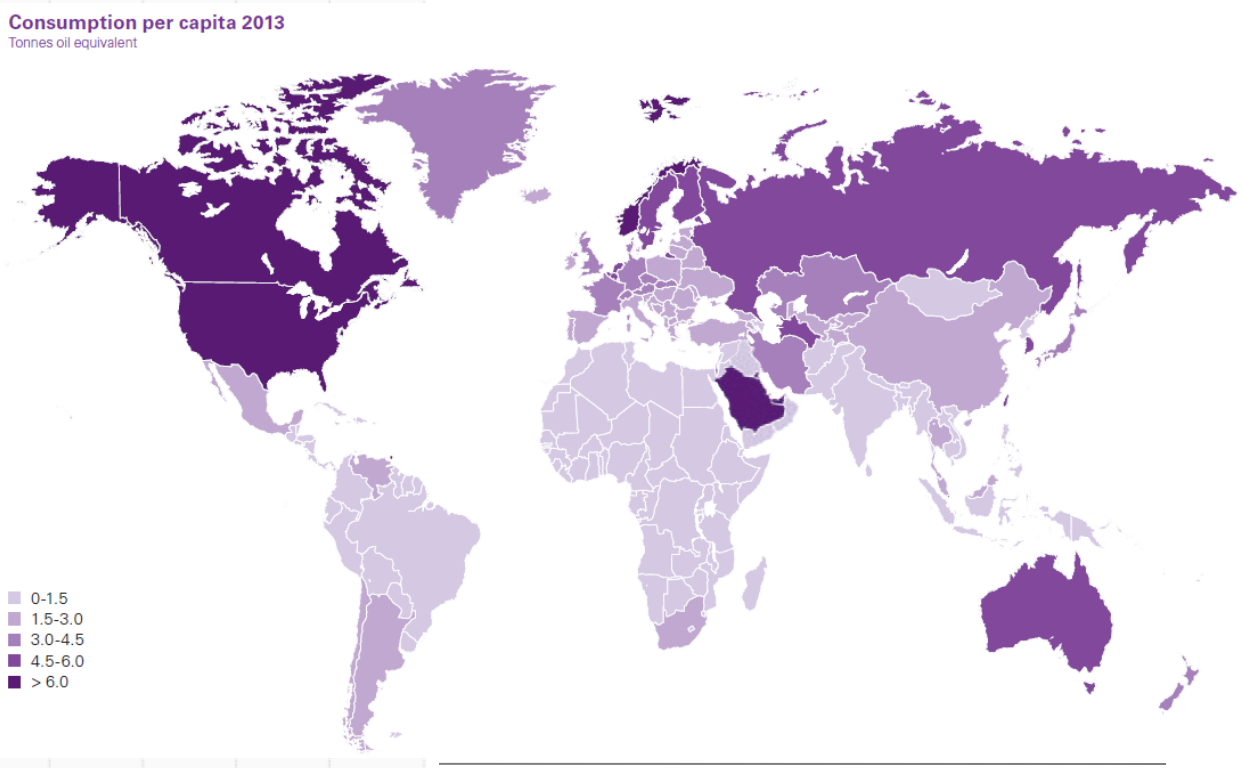


Breyer C, Gerlach A. **Global overview on grid parity**
Progress in photovoltaic: research and applications 2012. John Wiley & Sons, Ltd. DOI 10.1002/pip.1254

Price and consumption





statista.com; BP energy statistics review 2014

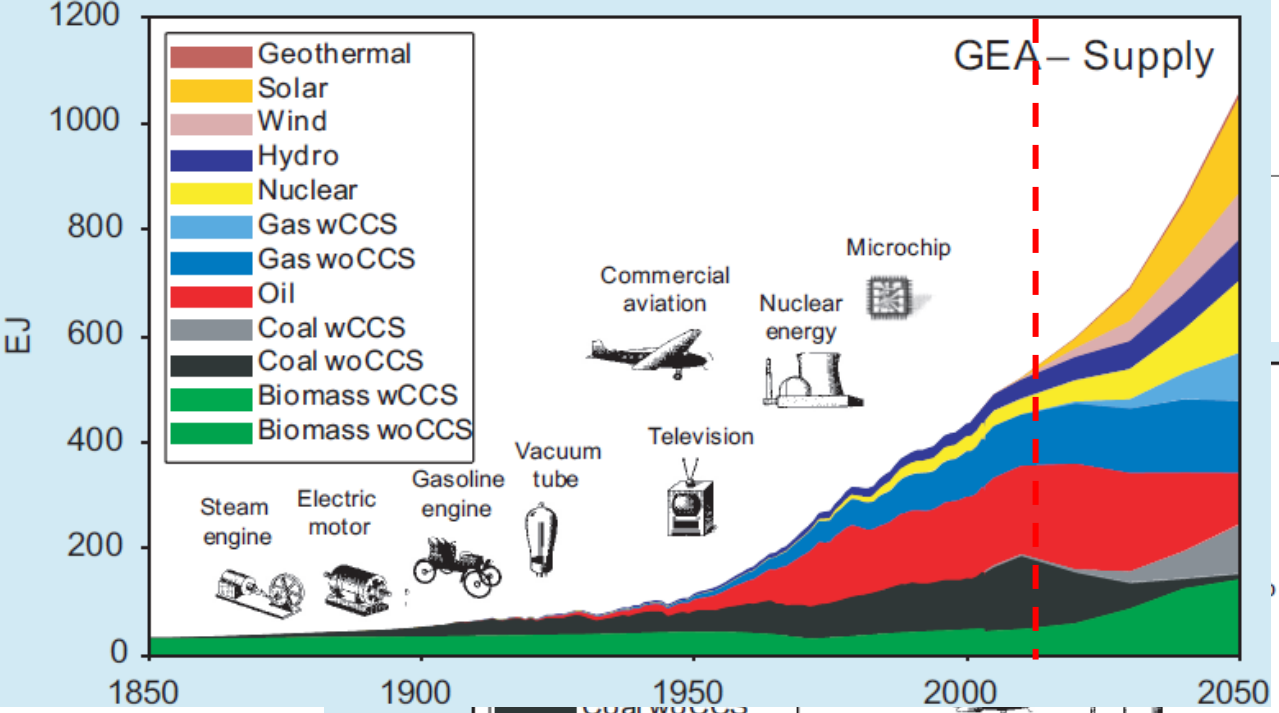
Price and Subsidies

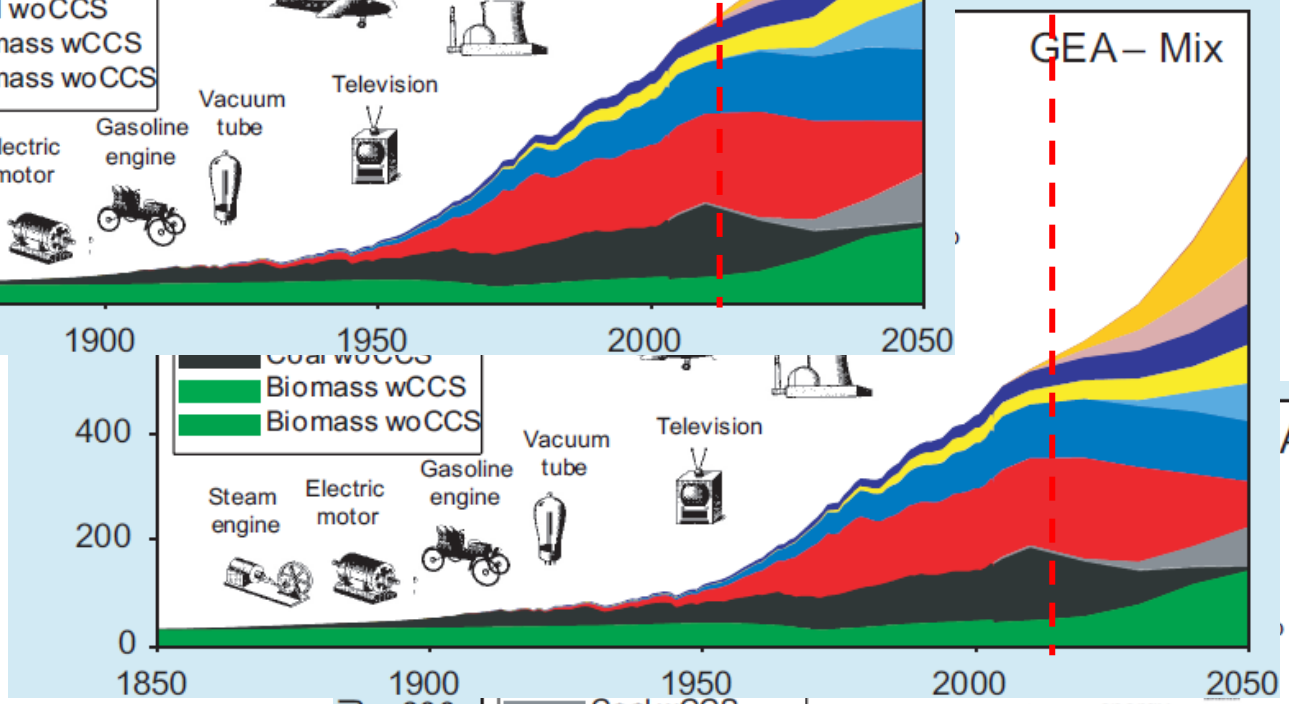
Global subsidies for fossil fuels : 523 B$ in 2011 (+ 27% from 2010)

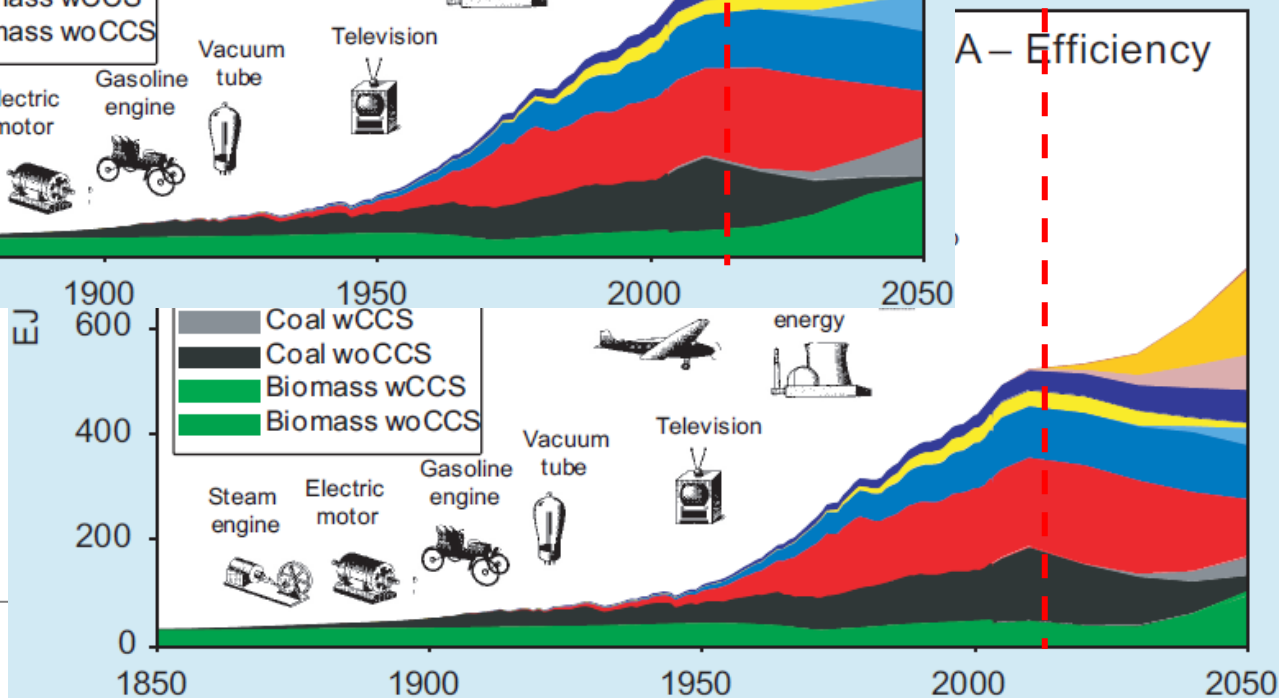
Global subsidies for renewables: 88 B$ in 2011 (+ 24% from 2010)

Future Trends

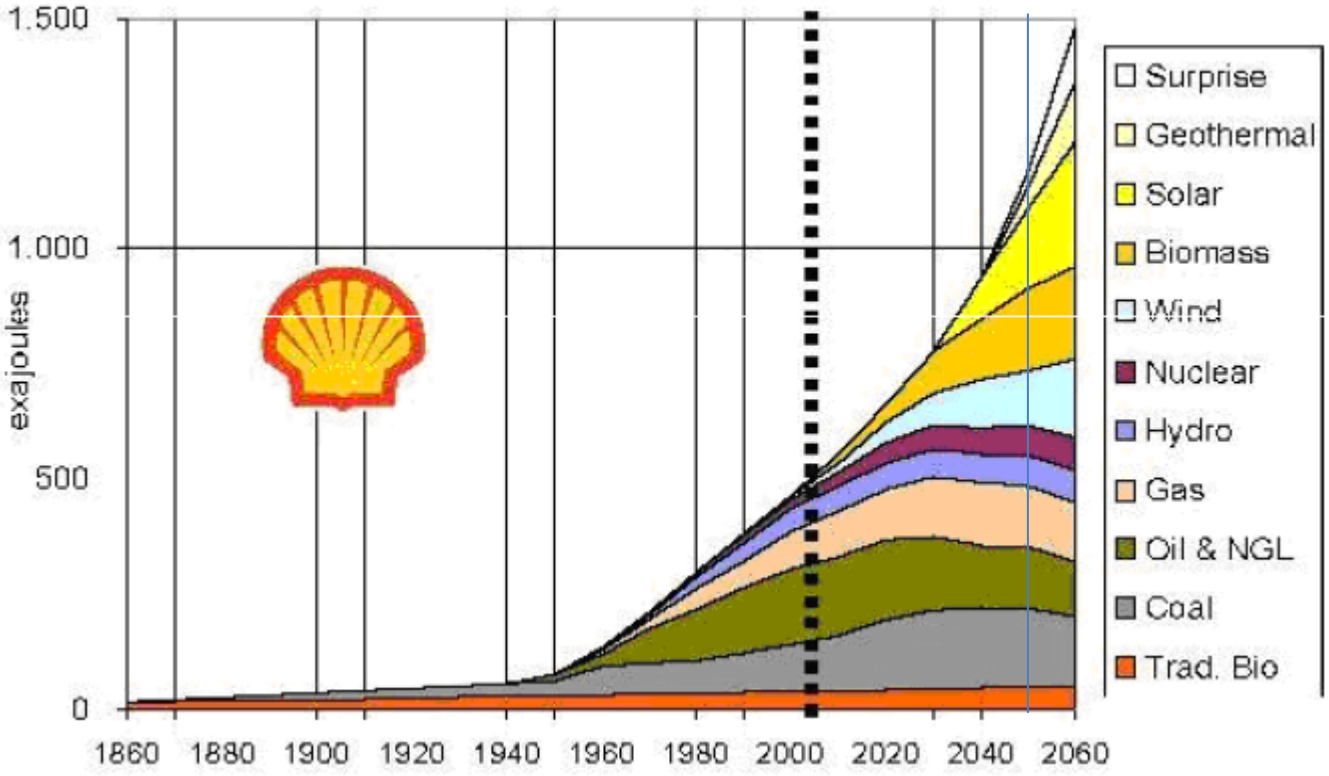
Scenarios (GEA)



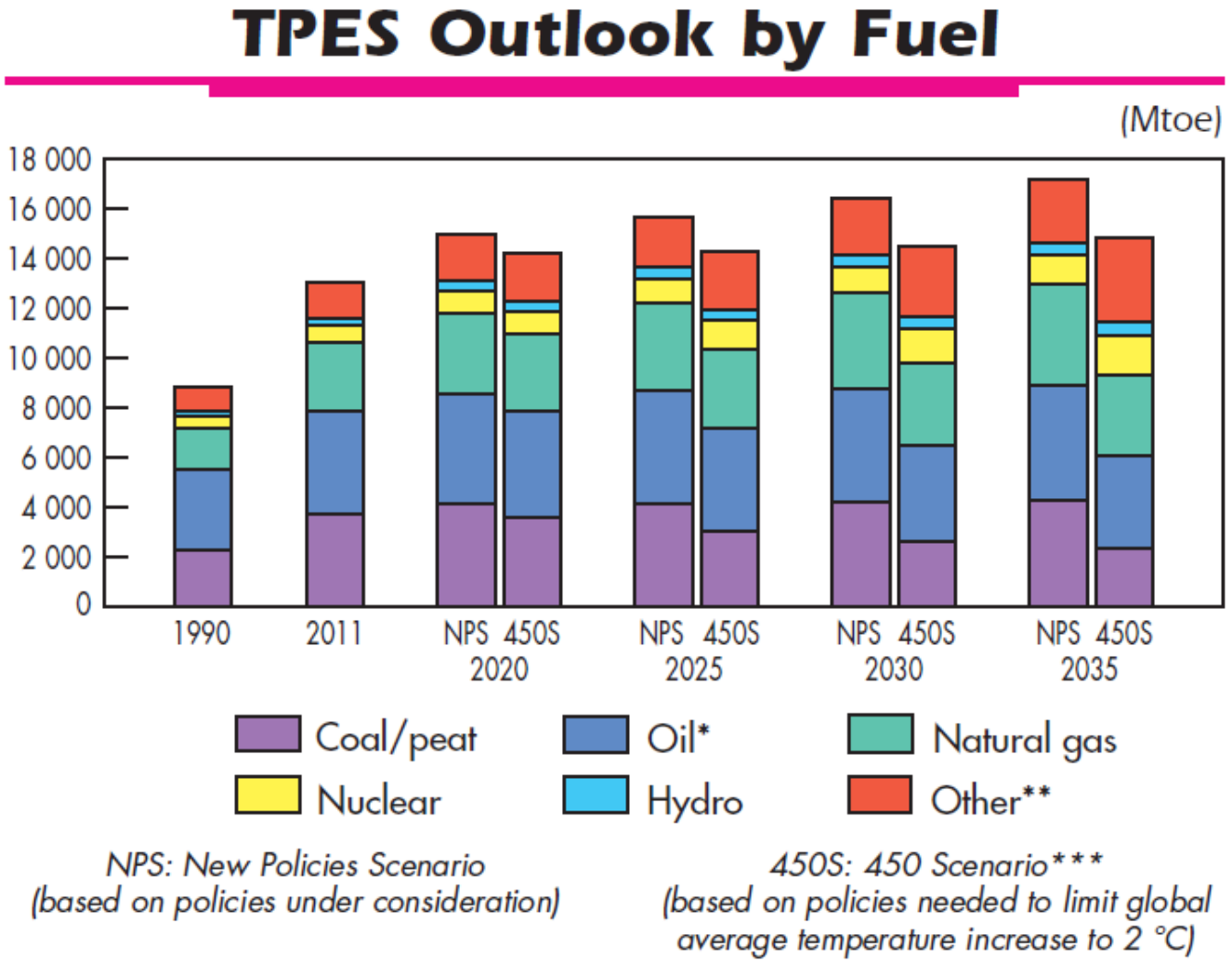




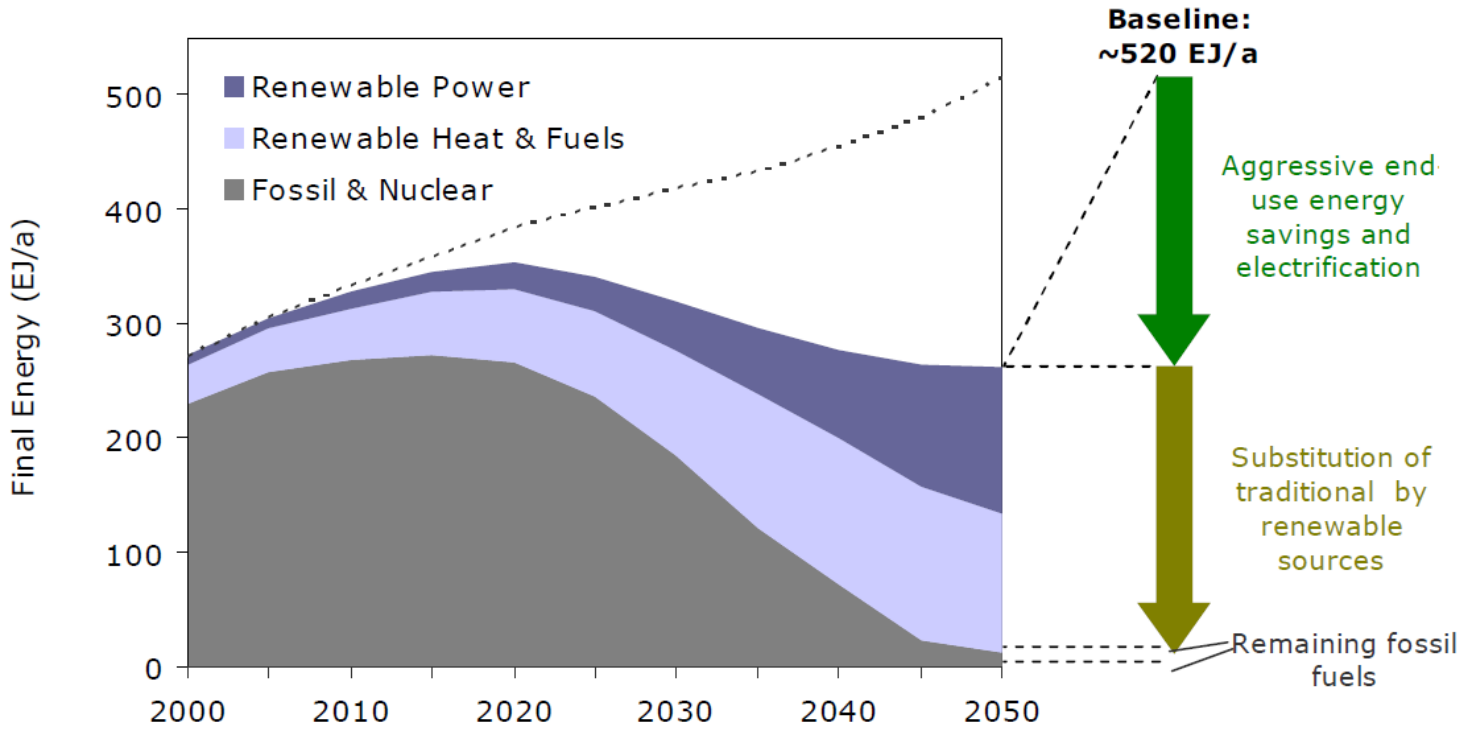
Scenario Shell (source-focused)



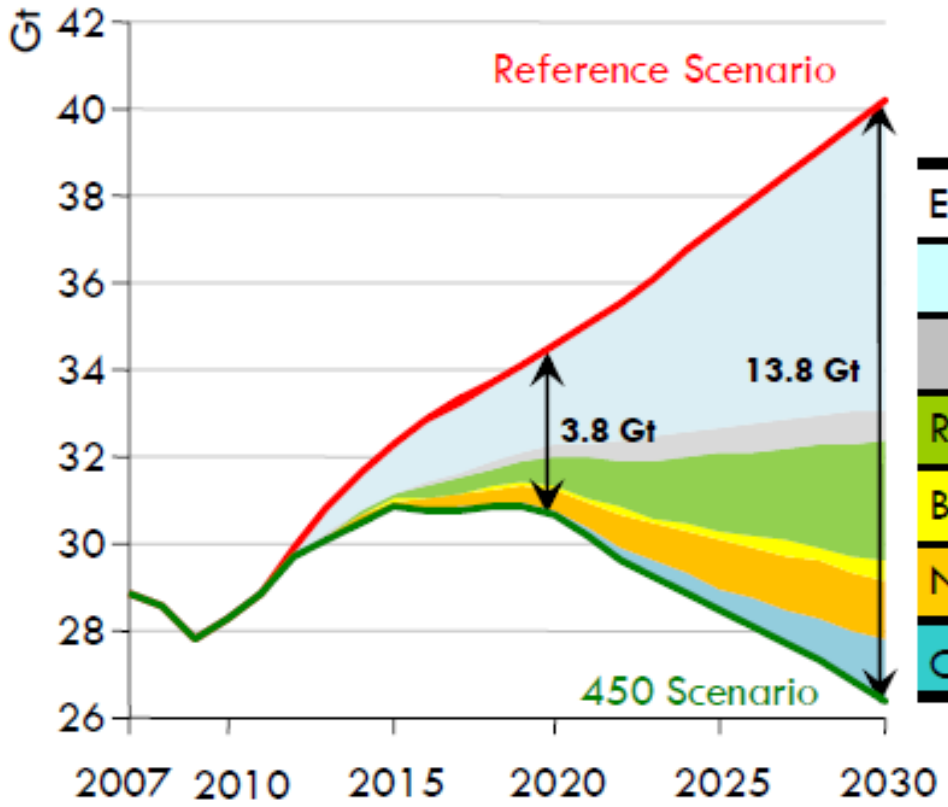
Scenario IEA (2013)



Scenario WWF (EcoFYS)



Energy: towards a carbon-free system



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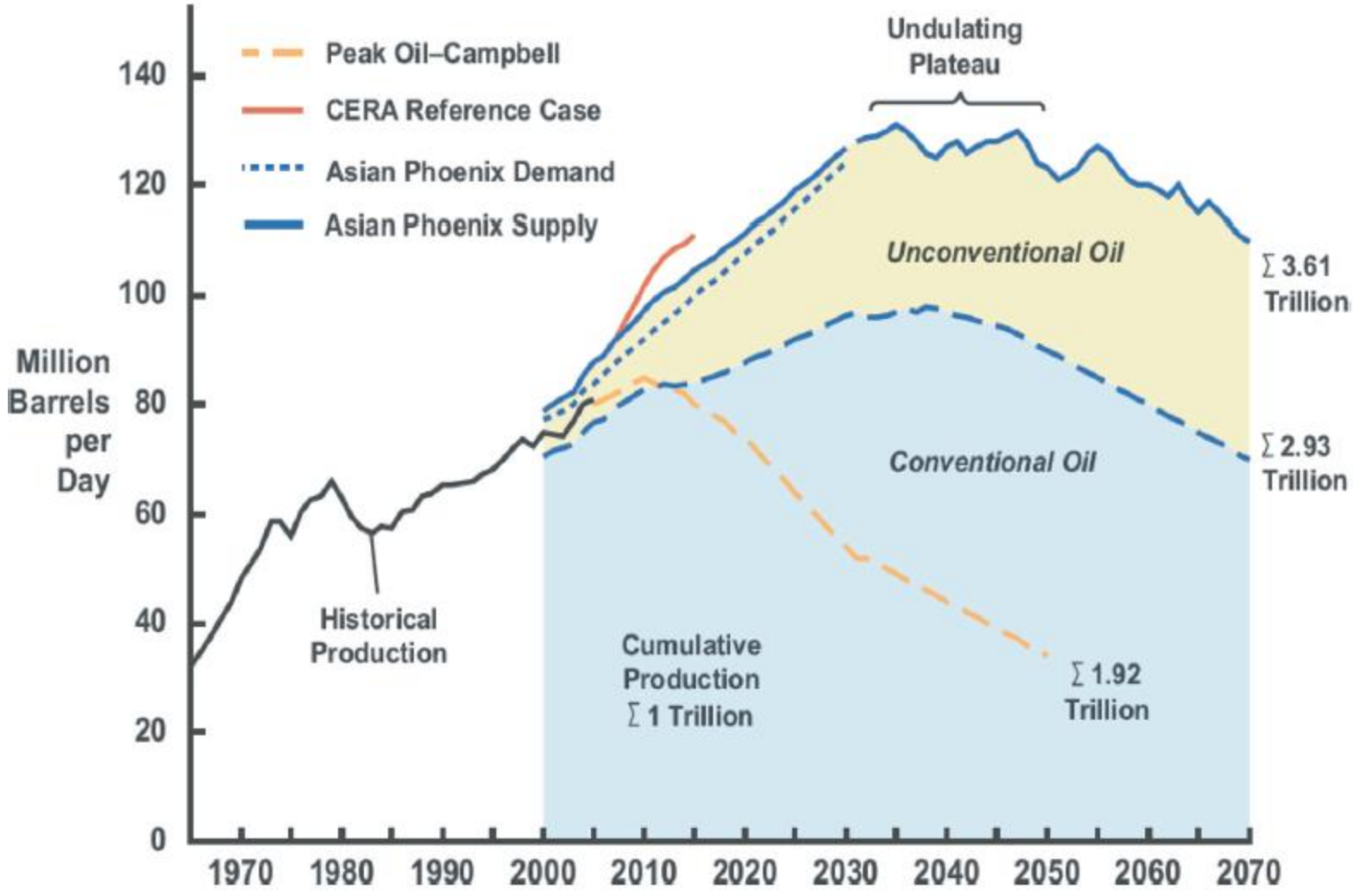
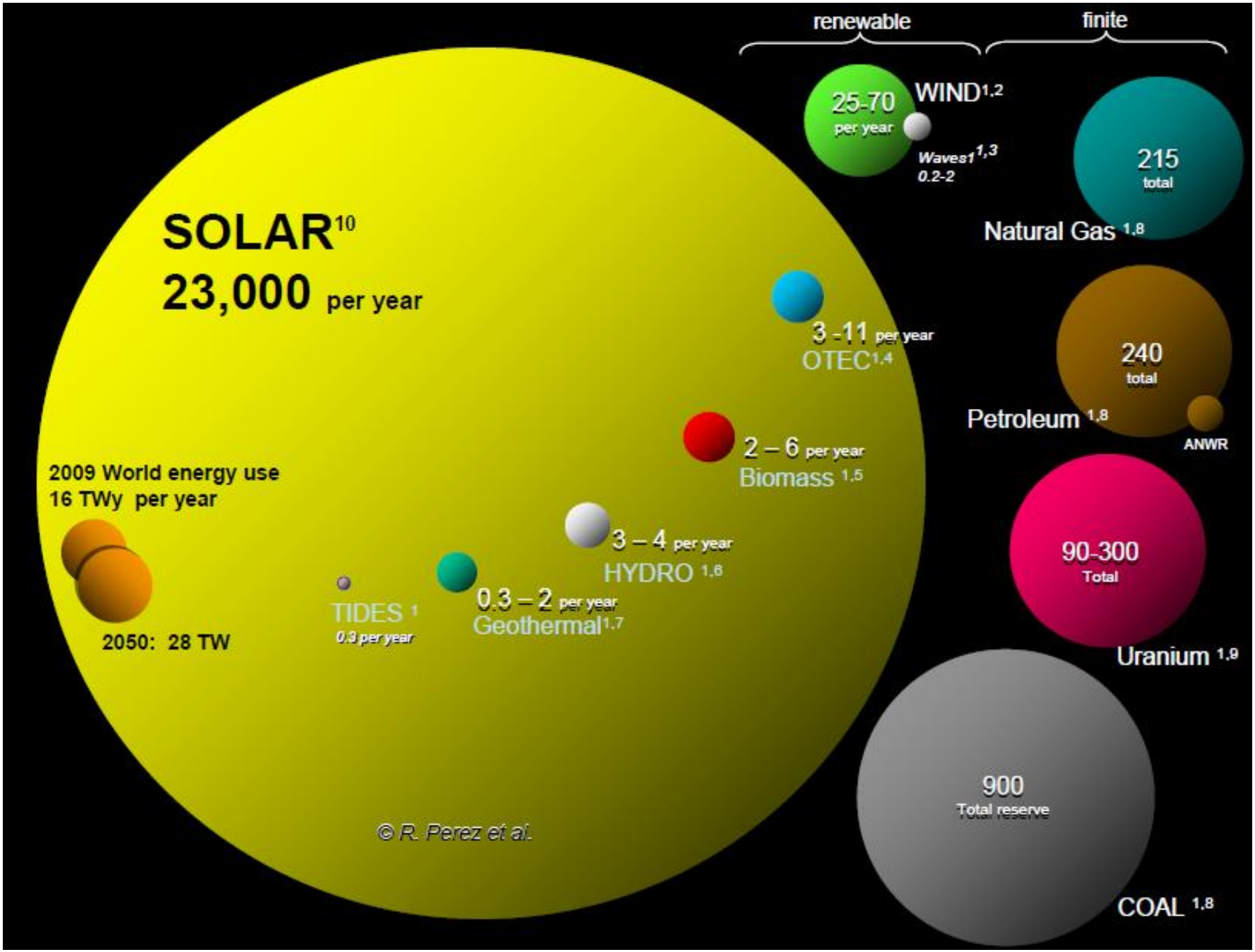
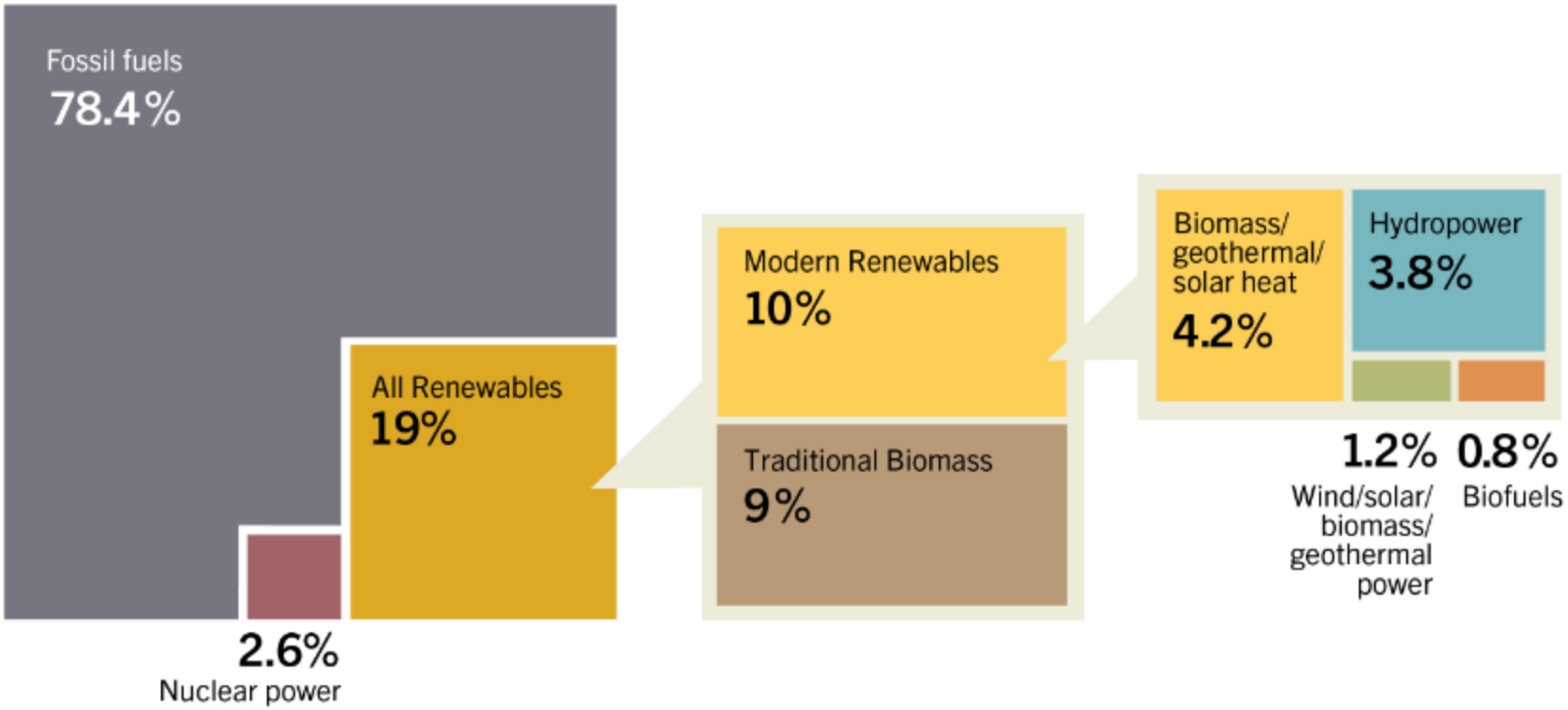
Oil is in fact going to end…




renewable
finite
SOLAR[10]
23,000 per year
25-70
per year
WIND[1,2]
Waves[1,3]
0.2-2
215
total
Natural Gas [1,8]
3 -11 per year
OTEC[1,4]
240
total
Petroleum [1,8]
ANWR
2 – 6 per year
Biomass [1,5]
2009 World energy use
16 TWy per year
3 – 4 per year
HYDRO [1,6]
90-300
Total
0.3 – 2 per year
Geothermal[1,7]
TIDES [1]
0.3 per year
2050: 28 TW
Uranium [1,9]
900
Total reserve
COAL [1,8]
© R. Perez et al.

Alternative resources

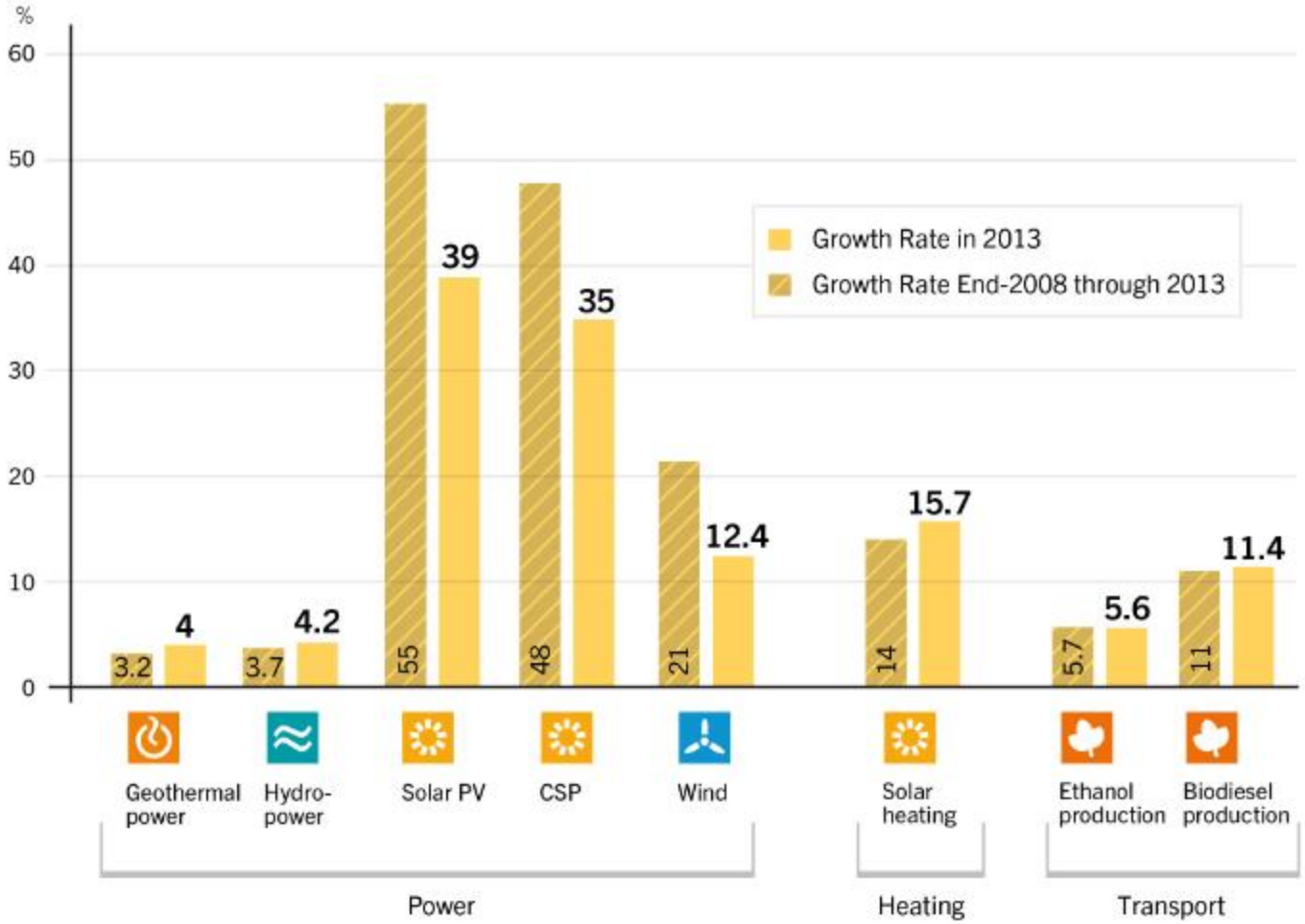
Estimated Renewable Energy Share of Global Final Energy Consumption, 2012



REN21. 2014. *Renewables 2014 Global Status Report*

Alternative resources

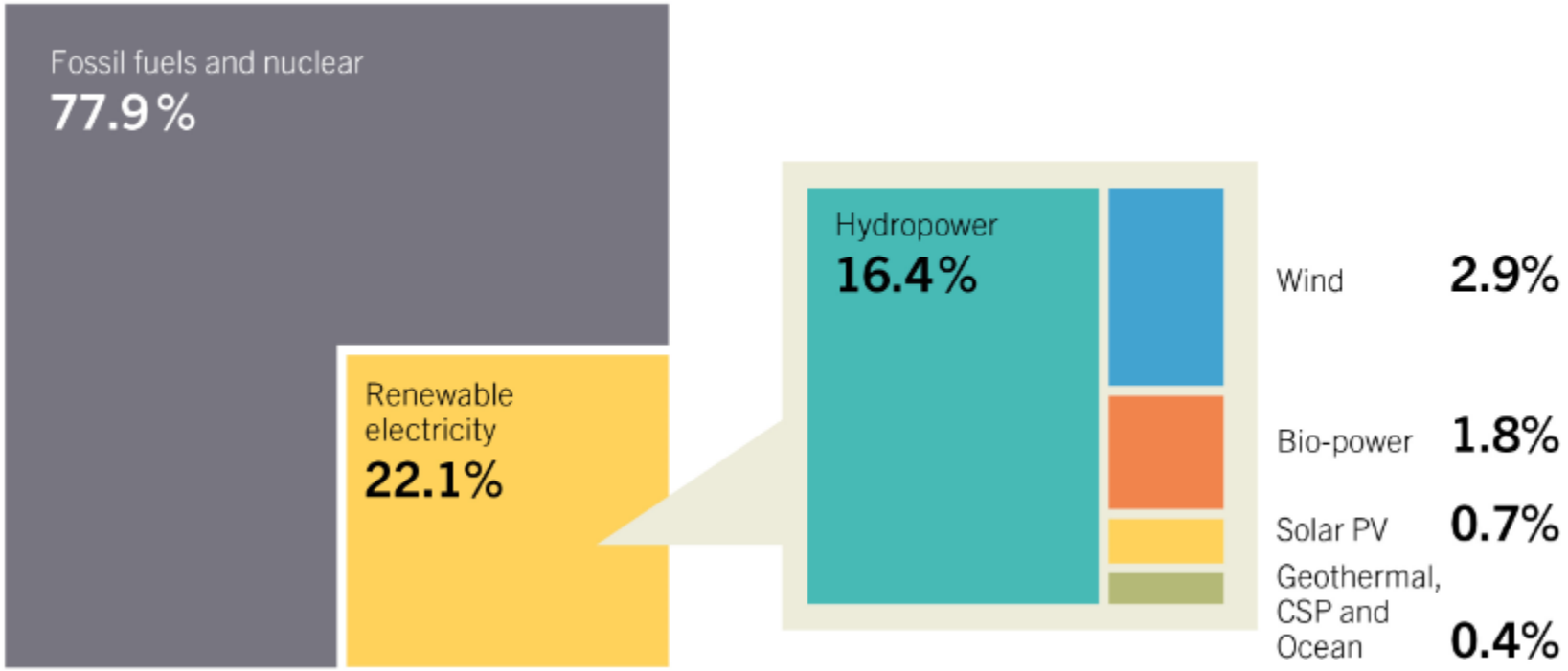
Average Annual Growth Rates of Renewable Energy Capacity and Biofuels Production, End-2008–2013



REN21. 2014. *Renewables 2014 Global Status Report*

Alternative resources

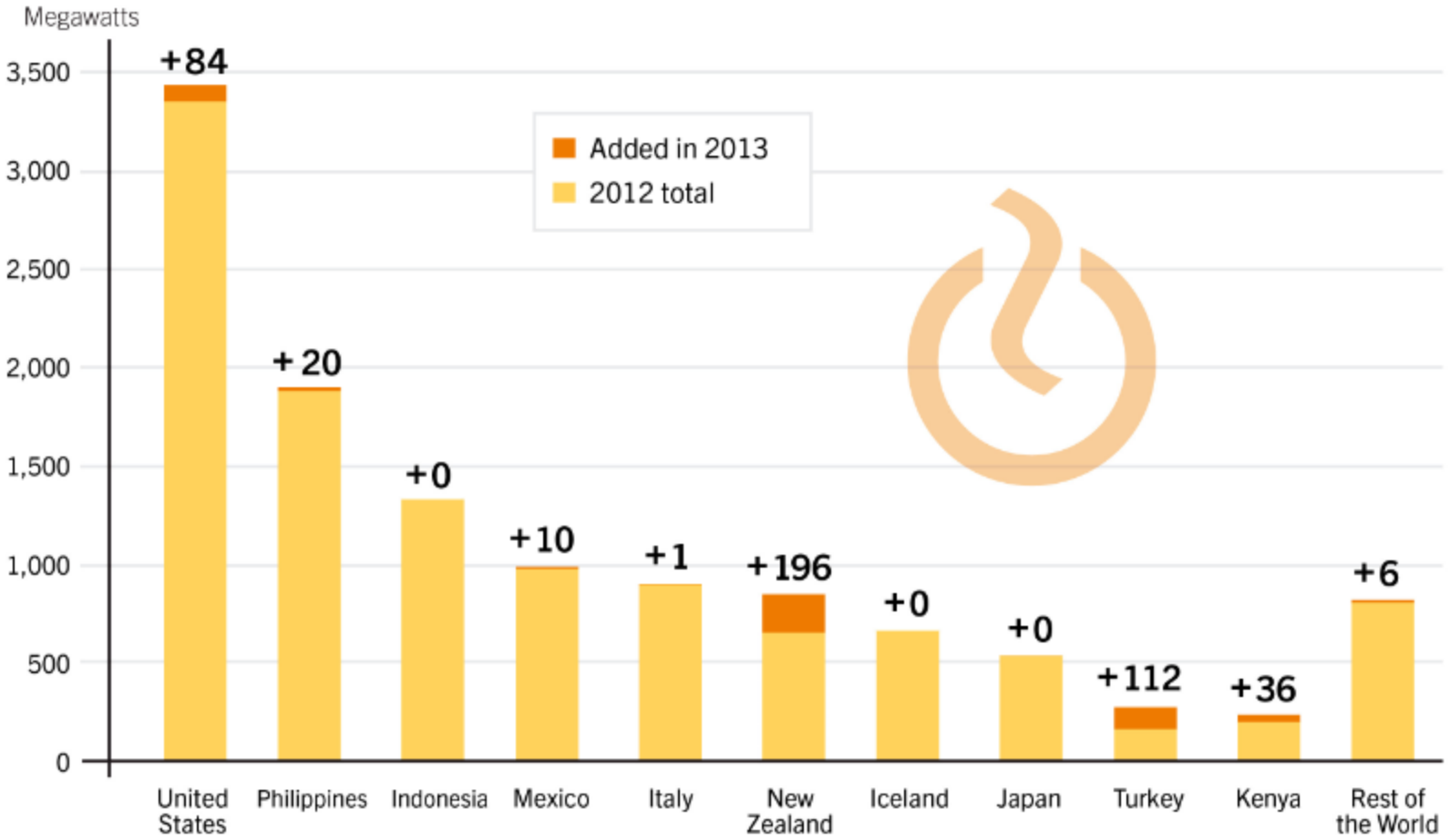
Estimated Renewable Energy Share of Global Electricity Production, End-2013



REN21. 2014. *Renewables 2014 Global Status Report*

Alternative resources

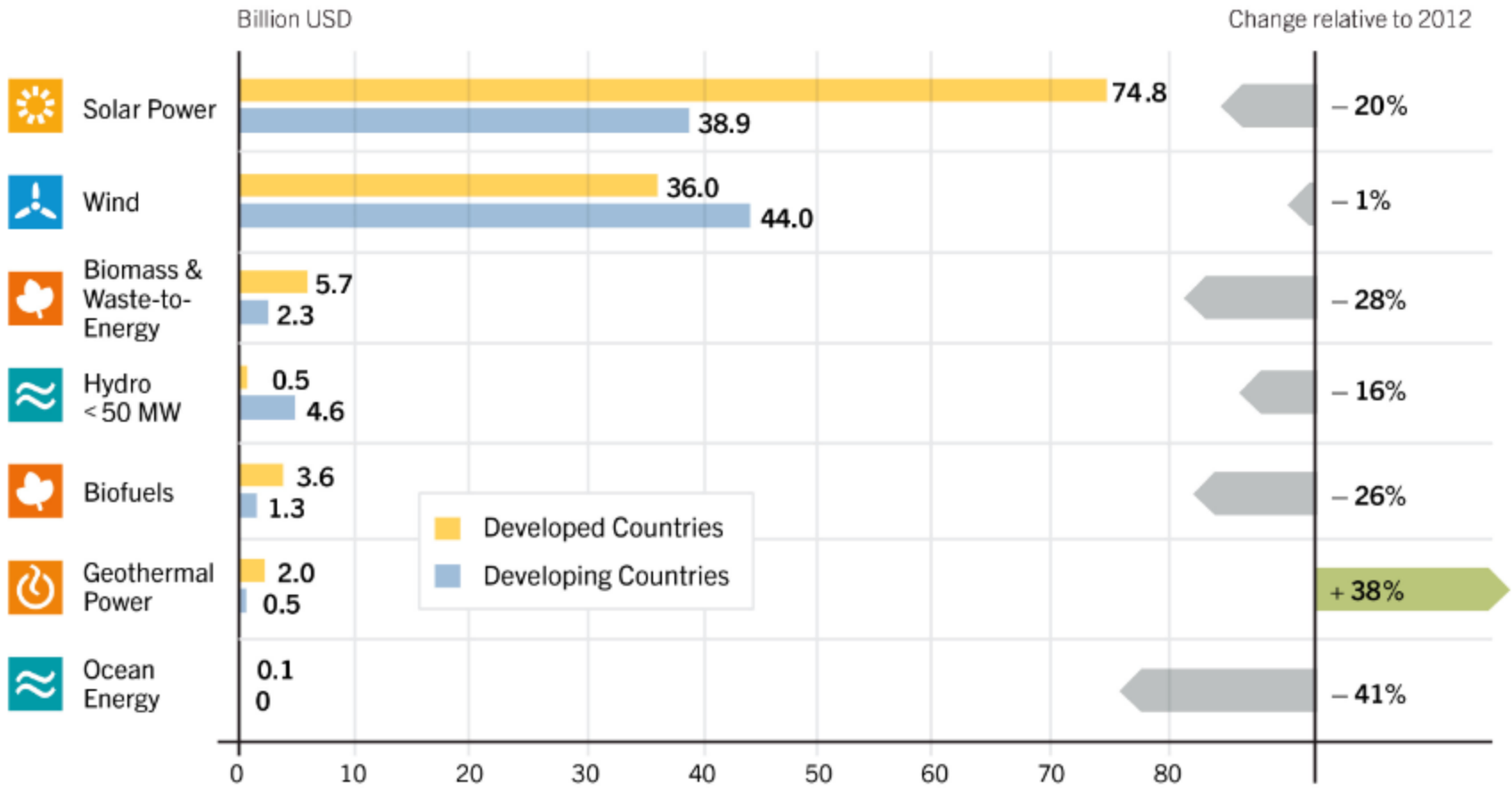
Geothermal Power Capacity and Additions, Top 10 Countries and Rest of World, 2013



REN21. 2014. *Renewables 2014 Global Status Report*

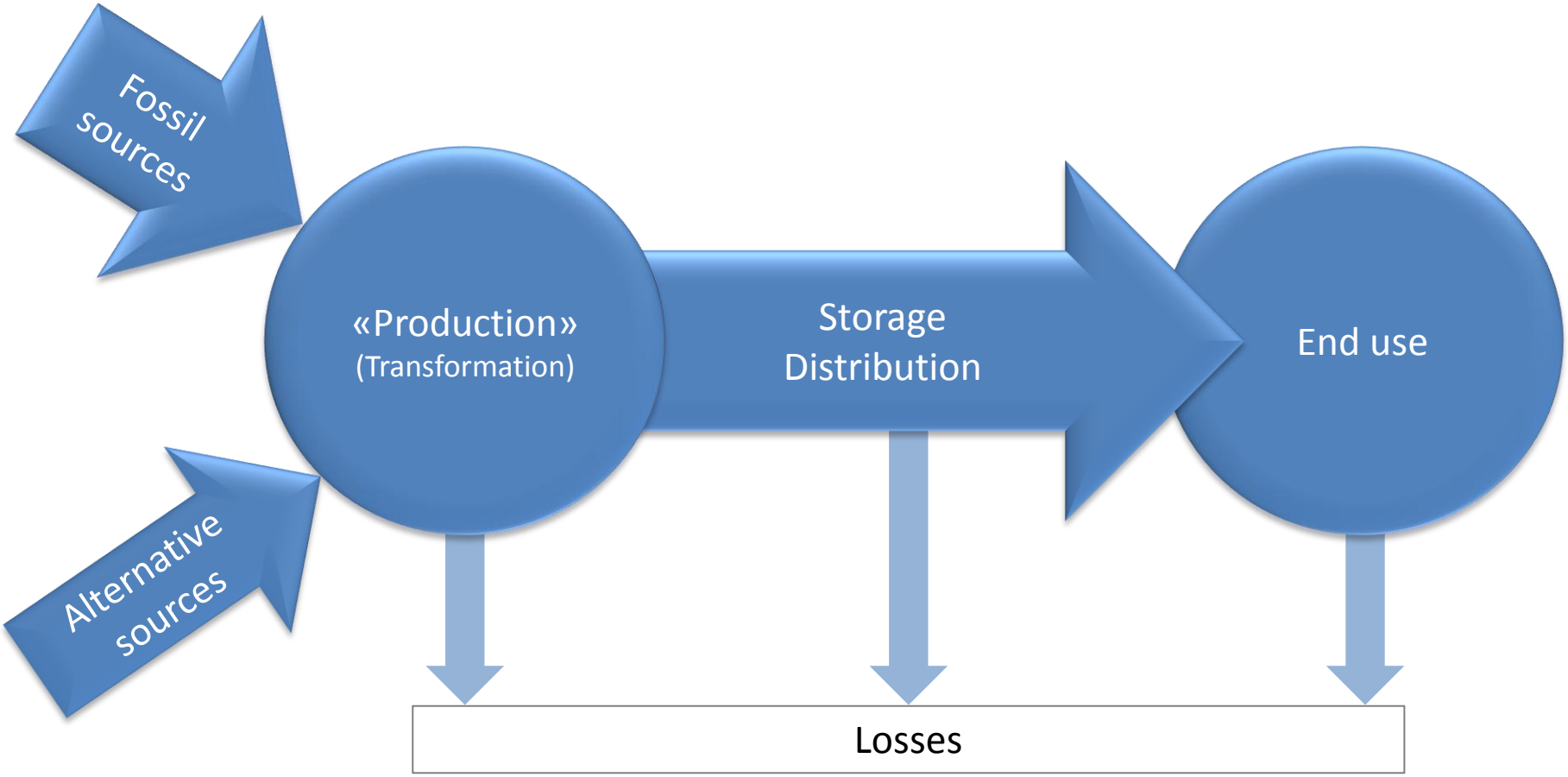
Alternative resources

Global New Investment in Renewable Energy by Technology, Developed and Developing Countries, 2013



REN21. 2014. *Renewables 2014 Global Status Report*

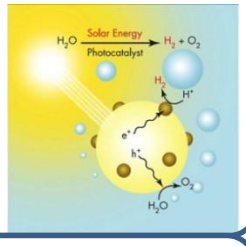
Energy Supply Chain



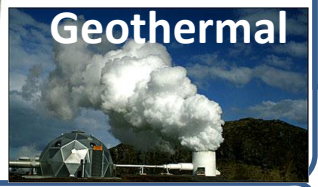
Imagine Future Scenarios

Production

Water electrolysis



Solar thermal



Biofuels

Storage, Transportation, and Distribution (electricity)

Storage, Transportation, Reconversion (Hydrogen)

Transportation (heat) – short distance

Transportation (fuel)

Use

- Energy as a **complex,** global issue
  - Interconnectedness with global issues
  - Many new players
- The «**Energy Chain**»: from the source to the final use
  - Key role of energy efficiency and savings
- **Trends and outlooks** in energy demand, supply and price
  - The disruptive role of gas
  - Lessons learned from photovoltaics
- Tools for assessing **energy quality**
- **Trends** in energy technology
- The **Peri-Adriatic** Region

Carbon Footprint

Amount of ***CO_2 equivalent*** **emitted**

- by a population, system or activity
- within a space- and timeframe

Footprint is commonly calculated for:

- Individuals, households, populations
- Energy production systems
- Products

Carbon Footprint – GHG emissions

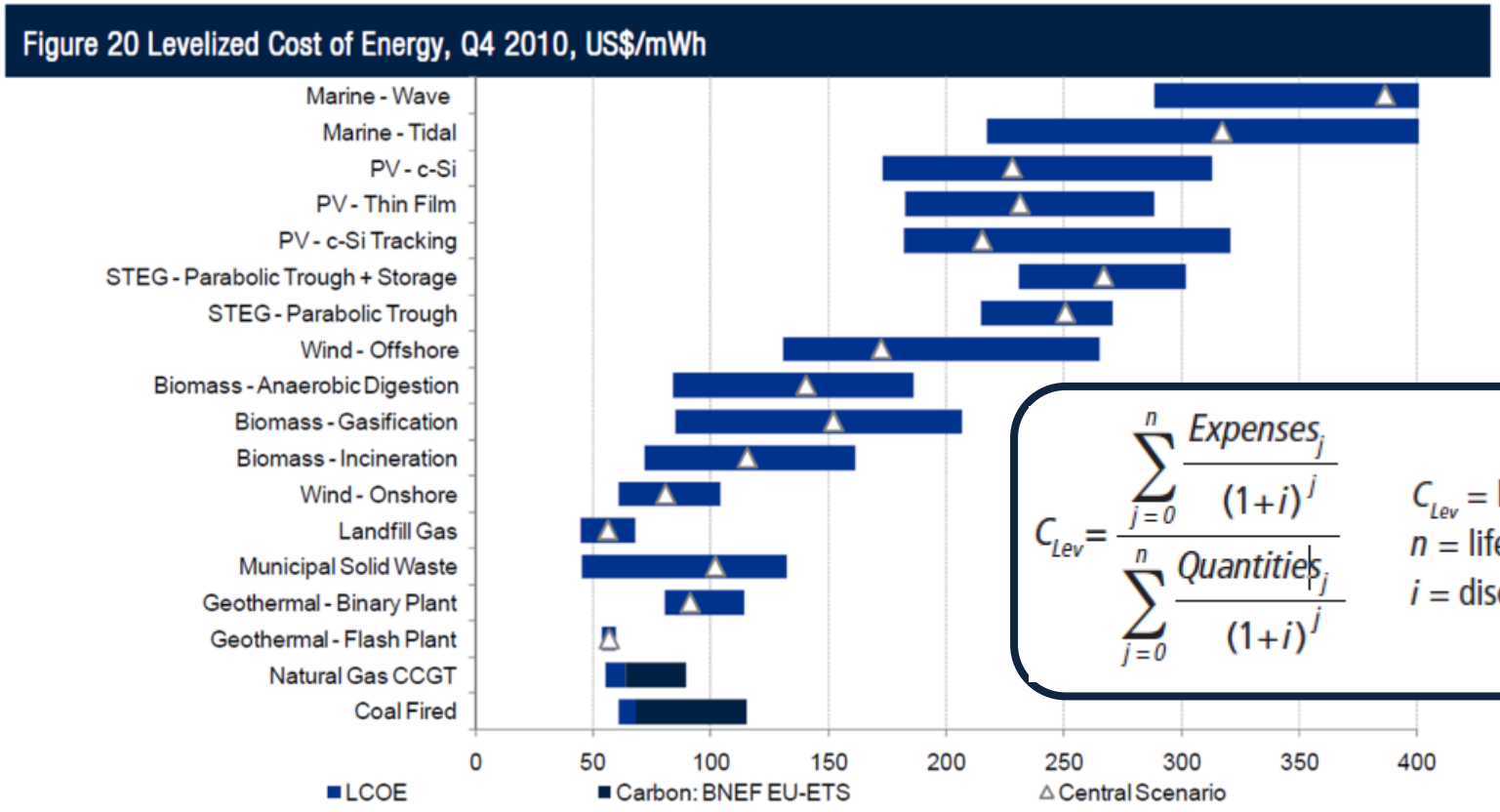
Table A.II.4 | Aggregated results of literature review of LCAs of GHG emissions from electricity generation technologies as displayed in Figure 9.8 (g CO_2eq/kWh).

Values	Bio-power	Solar		Geothermal Energy	Hydropower	Ocean Energy	Wind Energy	Nuclear Energy	Natural Gas	Oil	Coal
		PV	CSP								
Minimum	-633	5	7	6	0	2	2	1	290	510	675
25th percentile	360	29	14	20	3	6	8	8	422	722	877
50th percentile	18	46	22	45	4	8	12	16	469	840	1001
75th percentile	37	80	32	57	7	9	20	45	548	907	1130
Maximum	75	217	89	79	43	23	81	220	930	1170	1689
CCS min	-1368								65		98
CCS max	-594								245		396

Note: CCS = Carbon capture and storage, PV = Photovoltaic, CSP = Concentrating solar power.

http://srren.ipcc-wg3.de/report/IPCC_SRREN_Annex_II.pdf

LCOE – Levelized Cost of Energy



$$C_{Lev} = \frac{\sum_{j=0}^{n} \frac{Expenses_j}{(1+i)^j}}{\sum_{j=0}^{n} \frac{Quantities_j}{(1+i)^j}}$$

C_{Lev} = levelized cost
n = lifetime of the project
i = discount rate

Dynamic calculator: http://en.openei.org/apps/TCDB/

EROEI

Energy Return On Energy Invested:

$$EROEI = \frac{E_{out}}{E_{in}}$$

E_{out}: energy provided by the system over its lifetime
E_{in}: total energy required to create and operate the system

100.0	Hydro
80.0	Coal
35.0	Oil imports 1990
35.0	World oil production
30.0	Oil and gas 1970
20.0	Oil production
18.0	Wind
18.0	Oil imports 2005
14.5	Oil and gas 2005
12.0	Oil imports 2007
10.0	Nuclear
10.0	Natural gas 2005
8.0	Oil discoveries
6.8	Photovoltaic
5.0	Ethanol sugarcane
5.0	Shale oil
3.0	Bitumen tar sands
1.9	Solar flat plate
1.6	Solar collector
1.3	Ethanol corn

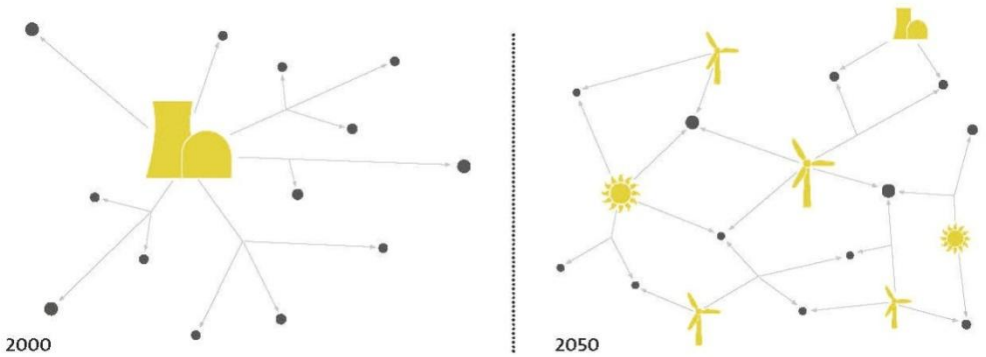
Geothermal: 6 - 39

Gupta et al., Sustainability 2011, 3, 1796

Concluding remarks

Trends

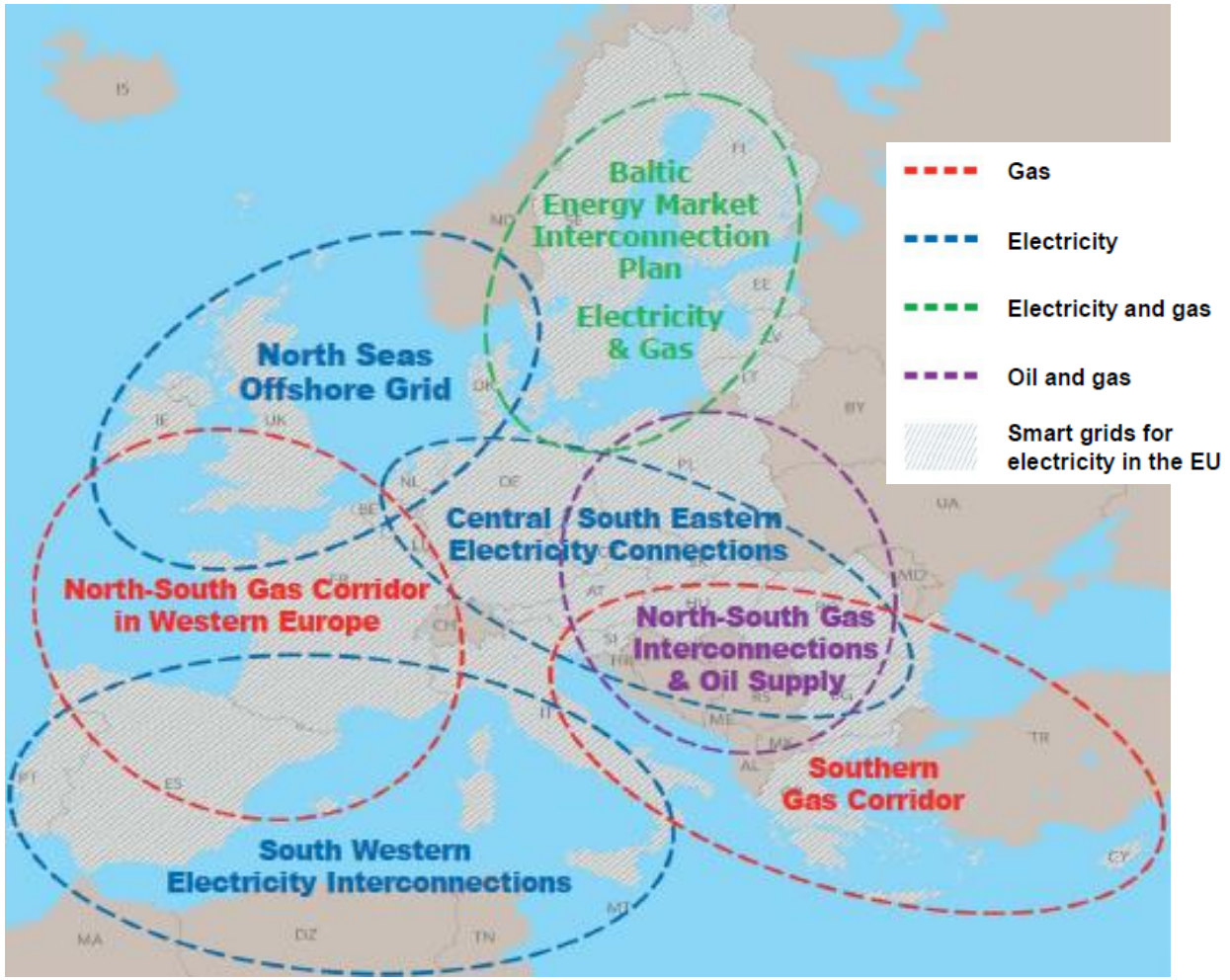
- **Diversification** of the energy sources (mostly alternative/renewable)
  - **Mini- and microgeneration**
  - «**Democratization**» of energy
  - Principle of **locality** of the source
  - **Integration** of energy sources
  - Higher **complexity**



- **Storage**
  - **Large scale** to compensate unpredictability of renewable resources
  - **Small scale** to enable reliability of local (integrated) systems

Key role of social aspects! (see for example the case of photovoltaics in Italy)

Scenarios in the Peri-Adriatic Region



Source: EU Commission

Scenarios in the Peri-Adriatic Region

Corridor opening options (2018 - Shah Deniz II)

- Nabucco-West
- Trans-Adriatic Pipeline
- Trans-Anatolian Pipeline & South-Caucasus Pipeline

Corridor enlargement

- Extension of transport routes & new transport routes

oil and gas exploration

Need for clear, shared, coherent and long-sighted policies and regulations!

Source: EU Commission